Popular Astronomy

Vol. XLVIII, No. 4 APRIL, 1940 Whole No. 474

The Schmidt Camera

By CHARLES H. SMILEY

II. Chromatic Aberration and Other Factors Governing Design

This paper is to be considered as supplementary to an earlier paper by the same author.[11] The design of the correcting plate, (here assumed to consist of a single element), to provide a minimum of chromatic aberration will be discussed. It will be shown that in faster cameras, the neutral zone will lie nearer the edge of the correcting plate; that for ordinary Schmidt cameras thus corrected for a minimum chromatic aberration, there is a limiting focal ratio of about f/0.5. A graphical representation of the relations of nominal focal ratio, ratio of diameters of correcting plate and mirror, and diameter of field will be given. In conclusion, a reasonably complete bibliography on the Schmidt camera will be presented.

Chromatic Aberration. It may be recalled that the purpose of the correcting plate which is placed at the center of curvature of the spherical mirror in a Schmidt camera is to eliminate spherical aberration. Furthermore, since chromatic aberration enters only through the action of this correcting plate, any minimizing of this aberration will be achieved by appropriate shaping of the correcting plate.

To simplify the discussion, let the correcting plate be assumed to have one plane surface and let that surface be turned toward the incident light. (Later one may choose to divide the curvature between the two surfaces.) There will then be a single infinitude of surfaces for the other side which will eliminate spherical aberration. It may be well to pause for a moment and examine the character of this infinite sequence of surfaces.

Consider a parallel bundle of rays striking a concave spherical mirror. One ray will be reflected back on itself; call this the axis of the bundle and consider narrow circular zones on the spherical mirror, each with its center on the axis. Each zone will reflect rays to a different focus; the foci corresponding to the inner zones will lie farther from the mirror than those which correspond to the outer zones. (See Figure 1.)

One may choose the focus corresponding to any one of these zones (or in fact another point on the same line) and design the correcting plate in such a way that all of the zones of the mirror will reflect the rays of the parallel bundle to this point. It is clear that for an ordinary Schmidt, this chosen focus must lie between the spherical mirror and the

correcting plate. It will be seen that the choice of this point amounts to the choice of the position of the neutral zone in the correcting plate; rays passing through this neutral zone are not deviated by the plate. It will be convenient to denote by η, the ratio of the distance of the neutral zone from the center of the correcting plate to the radius of the plate. Thus when $\eta = 1$, the neutral zone will be at the edge of the plate. η will always be positive or imaginary, never negative. It may be greater than one.

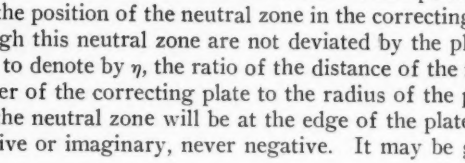


FIGURE 1

In his original article describing the camera, B. Schmidt[1] pointed out that the chromatic aberration introduced by the correcting plate might be minimized by giving to the plate such a form that its central part acts as a weakly convergent lens while the outer part has a weakly divergent effect. He suggested that if one placed the neutral zone so that $\eta = 0.866$, the chromatic aberration would then be a minimum. Schmidt did not specify more precisely the form to be given to the correcting plate nor did he indicate the mathematical basis for his statement that chromatic aberration would be minimized by placing the neutral zone at the position indicated.

F. B. Wright[9] developed independently the mathematics of a generalized Schmidt camera corresponding to the application of the Schwarzschild theory to a lens-mirror system. As the condition for minimum chromatic aberration, he proposed that the slope of the axial section of the plate at a point halfway to the edge should be equal to the negative of the slope at the edge; this corresponds to $\eta = 0.866$ if one uses the third-order equation of the axial section of the plate.

B. Strömgren[8] presented a beautiful mathematical development of the third-order theory of the form which must be given to the correcting plate to minimize chromatic aberration. He credited Schmidt with having informed him by letter on this point. The equation of the axial sec-

tion of this form of correcting plate he gave as:

$$y = (2x^4 - 3H^2x^2)/(64n - 64)$$

where the ratio of aperture to focal length is $2H$:1 and n is the index of refraction of the glass from which the plate is made, for the chosen wave-length. x and y are here measured in units of the focal length. It is seen that, according to the third-order theory, the position of the neutral zone is independent of the glass used and of the focal ratio of the camera, that

$$\eta = \sqrt{3}/2 = 0.866.$$

The author of the present article gave an elementary mathematical development[11] of the form of the correcting plate based on geometrical optics. He pointed out that the position of the neutral zone was a function of the focal ratio and that for an f/1 camera, $\eta = 0.87667$. This result was obtained by minimizing the chromatic circle of confusion about a point-focus corresponding to the particular wave-length for which the correcting plate was computed. As had been pointed out earlier by Strömgren, this circle will have a minimum area provided the outward deviation of paraxial rays striking the edge of the correcting plate is just equal to the maximum inward deviation of similar rays striking elsewhere on the plate. On this basis, the positions of the neutral zone have been computed for various focal ratios likely to be used in Schmidt cameras. The results of these calculations, which have been carried through with the assistance of Mr. Harry Rodin, are presented

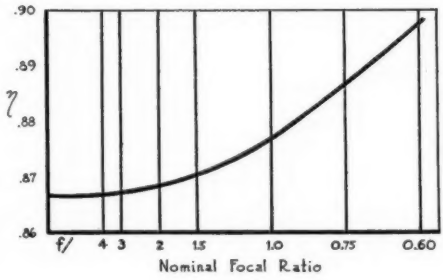


FIGURE 2

graphically in Figure 2. The abscissa is the nominal focal ratio; the ordinate is η, the ratio of the distance of the neutral zone from the center of the plate to the radius of the plate.

It will be noted that for the slower Schmidt cameras, the third-order theory will give a good approximation to the proper position of the neutral zone, but that for faster cameras, the neutral zone should be nearer the edge than $\eta = 0.866$.

Before leaving the question of the best position of the neutral zone, it may be well to point out that other considerations may outweigh the min-

imizing of chromatic aberration. Strömgren[8] called attention to the possibility of making an achromatic correcting plate from elements of crown and flint glass. He also showed that by making η less than 0.866, the effects of diffraction could be masked, in particular, that if the circle of confusion due to spherical aberration is of the same order of size as the diffraction disk, η should be chosen equal to 0.707.

Hendrix and Christie[30] have pointed out that placing the neutral zone at $\eta = 0.707$ leads to ease in construction and minimizes the amount of glass to be removed. This choice allows the edge of the finished correcting plate to be just as high as the center. It may be noted here that two and a half times as much glass must be removed in making a plate for which $\eta = 0.866$ as in one for which $\eta = 0.707$. However, Messrs. H. W. and L. A. Cox[19] have shown that the curved surface of the correcting plate may first be given a convex spherical form of appropriate curvature and thus the amount of glass to be removed in the delicate operations of figuring is greatly reduced. Approximately two-thirds of the glass to be removed in making a plate for which $\eta = 0.866$ may be ground away in this preliminary work.

One may note in passing the clever method of grinding the correcting plate which was introduced by E. H. Linfoot.[25] A lead lap of uniform thickness is used in which the lead is "cut away so that the amount of lead passing in a given time over any part of the plate is proportional to the depth of glass to be removed."

Limiting Focal Ratio. Next it is noted that there is a natural limit to the focal ratio which may be achieved in an ordinary Schmidt camera with correcting plate designed for minimum chromatic aberration. It is seen from Figure 2 that as the focal ratio increases, η increases, coming nearer to one. One may assume that $\eta = 1$ and determine the focal ratio for which the rays striking the edge of the correcting plate come in tangent to the focal surface. Since, for $\eta = 1$, the neutral zone lies at the edge of the correcting plate, the rays which are to be tangent to the focal surface must come to the natural focus for a zone of the spherical mirror equal in diameter to the correcting plate. Thus the angle of incidence and the angle of reflection at the edge of the spherical mirror must each be 45°; the diameter of the correcting plate will be twice the focal length of the camera and therefore, under the assumptions named, the limiting nominal focal ratio is f/0.5. A sketch of such a camera is shown in Figure 3.

At this point, it is well to remind the reader that this result is of purely theoretical interest, that f/0.6 is probably nearer the practical limit under the conditions named. If one is willing to accept a camera with an amount of chromatic aberration considerably greater than the minimum, even faster Schmidts are possible. Also it is well known that cameras employing the Schmidt principle but deviating from the ordinary Schmidt pattern can be constructed with speeds greater than f/0.5. It

does not seem worth while here to take into account the fact that the assumption $\eta = 1$ is not precisely satisfied and to redetermine the limiting focal ratio under another assumption nearer the true value of η.

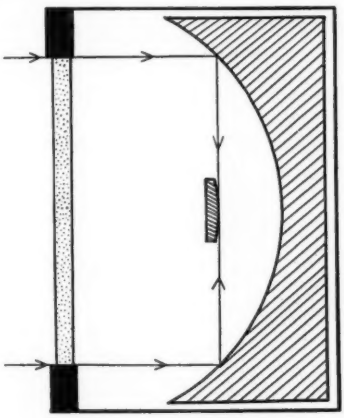


FIGURE 3

One interesting result of the discussion just completed is to call attention to the fact that the focal length of a Schmidt camera is measured from the center of the correcting plate to the focal surface, not from the vertex of the mirror as in the case of a simple paraboloidal mirror. To verify this, consider a ray coming in through the center of the correcting plate which is also the center of curvature of the spherical mirror. Theoretically, such a ray will strike the spherical mirror perpendicularly and will be reflected back along itself; practically it will strike the back of the film-holder and never reach the mirror. From the symmetry of the spherical mirror, it is seen that the focal surface must be spherical with center of curvature at the center of the correcting plate. Furthermore, it follows that a Schmidt camera gives a picture of the celestial sphere free from distortion; that is, a spherical triangle on the celestial sphere will produce a spherical triangle exactly similar on the focal surface.

Schmidt Camera Relations. Persons sometimes wish to prepare specifications for a Schmidt camera to serve a particular purpose, or even to construct such a camera, without studying in great detail the mathematical theory. For the convenience of such persons, the graphical representation of the relations between nominal focal ratio, the ratio of diameters—correcting plate to mirror—and the diameter of uniformly illuminated field has been prepared in Figure 4. No great originality is claimed here; all of the relations exhibited were included in Strömgren's article[8] in the form of mathematical equations. The abscissa is the nominal focal ratio, that is, the ratio of the diameter of the correcting plate to the focal

length of the camera. The ordinate is μ, the ratio of diameters, correcting plate to mirror. On this set of axes, five curves are drawn corresponding to fields 5°, 10°, 15°, 20°, and 25° in diameter. Here the fields are such that all parts are evenly illuminated with the exception that cameras with constants placing them in the cross-ruled area have fields

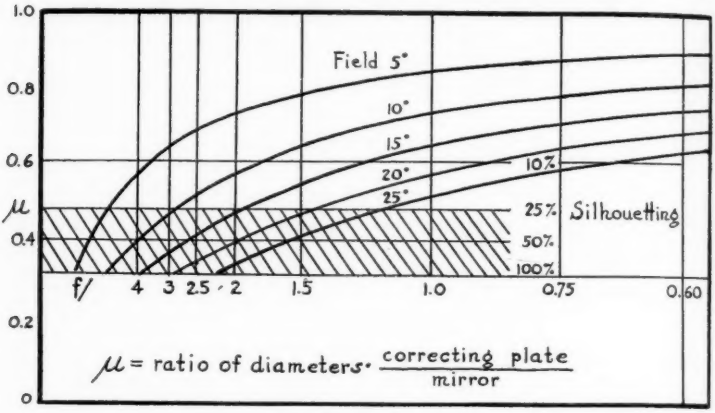


FIGURE 4

which diminish in illumination near the center, or in other words, the field of uniform illumination for cameras in the cross-ruled area is annular and of the diameter indicated. The percentages of silhouetting indicated for certain values of μ are those calculated for the center of the

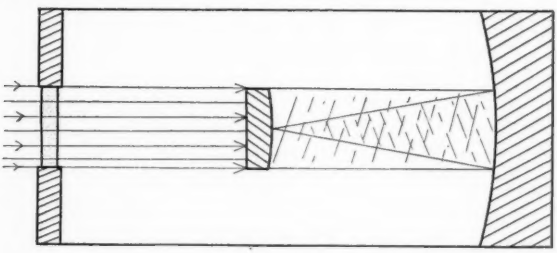


FIGURE 5

field. In Figure 5 is shown a sketch of a Schmidt camera with 100 per cent silhouetting at the center of the field. Such a camera might well prove useful in a coronagraph.

Returning again to Figure 4, it is seen that as the correcting plate is made larger and larger in comparison with the mirror, the uniformly illuminated field becomes smaller and smaller, until the point is reached at which the correcting plate is the same size as the mirror ($\mu = 1$) and the field of uniform illumination vanishes.

As an example of the use of the chart, suppose one wishes to use a correcting plate of 24 inches aperture with a mirror of 33 inches diameter to make a Schmidt camera of focal ratio f/3.5. μ will then be approximately 0.73 and it is seen that the field of uniform illumination will be about 3°-4° in diameter while less than 10 per cent of the incident light will be lost due to silhouetting.

It can be seen at once that in a camera of focal ratio, f/1 designed to cover 20°, the silhouetting must necessarily be greater than ten per cent. Likewise one notes that a field of uniform illumination of 20° is not possible with an f/1.5 camera.

In the bibliography that follows, an attempt has been made to list the papers in the order of their publication; any omission is unintentional. The surprising number of papers by amateurs in the list is a fair indication of the importance of their contribution to this field. One notes also how interest in the Schmidt camera has grown—four papers in the four years, 1931-4 and then thirty papers in the next five years. This interest is abundantly verified by the rapidly growing number of completed cameras.

BIBLIOGRAPHY

[1] Schmidt, Bernhard. Ein lichtstarkes komafreies Spiegelsystem. *Central Zeitung f. Optik u. Mechanik*, **52**, 1931.

[2] Konig, Albert. Doppelspiegel mit grosserem Gesichtsfeld. *Handbuch d. Astrophysik*, **1**, 170-1, 1933.

[3] Dunham, Theodore, Jr. The Use of Schmidt Cameras in Plane Grating Spectrographs. *Phys. Rev.*, 2nd series, **46**, 326, 1934.

[4] Ross, Frank E. The Optics of Reflecting Telescopes. *Publ. Astr. Soc. Pac.*, **46**, 339-345, 1934.

[5] Väisälä, Y. Anastigmatisches Spiegelteleskop der Sternwarte der Universität Turku. *Astr. Nach.*, **254**, 361-4, 1935.

[6] Dunham, Theodore, Jr. Schmidt Spectrograph Cameras. *Publ. Am. Astr. Soc.*, **8**, 110-1, 1935.

[7] Russell, Henry Norris. The Newer Telescopes. *Sci. Am.*, **152**, 294-5, 1935.

[8] Strömgren, B. Das Schmidtsche Spiegelteleskop. *Viert. d. Astron. Gesellschaft*, **70**, 65-86, 1935.

[9] Wright, Franklin B. An Aplanatic Reflector with a Flat Field Related to the Schmidt Telescope. *Publ. Astr. Soc. Pac.*, **47**, 300-4, 1935.

[10] Väisälä, Y. Uber Spiegelteleskope mit grossem Gesichtsfeld. *Astr. Nach.*, **259**, 197-204, 1936.

[11] Smiley, Charles H. The Schmidt Camera. *Pop. Astr.*, **44**, 415-421, 1936.

[12] Schorr, R. Das B. Schmidtsche Verfahren bei der Herstellung der Korrektionsplatten für Komafreie Spiegel. *Zeits. f. Instr.*, **56**, 175-7, 1936.

[13] Wright, Franklin B. Theory and Design of Aplanatic Reflectors Employing a Correcting Lens. *Amateur Telescope Making Advanced*, 401-9, New York, 1937.

[14] Lower, Harold A. Notes on the Construction of an F/1 Schmidt Camera. *Amateur Telescope Making Advanced*, 410-6, N. Y., 1937.

[15] Smiley, Charles H. The Construction of a Schmidt Camera. *Publ. Am. Astr. Soc.*, **9**, 19-20, 1937.

[16] Struve, Otto. A New Slit Spectrograph for Diffuse Galactic Nebulae. *Astrophys. Jnl.*, **86**, 613-9, 1937.

[17] Smiley, Charles H. Building and Using a Schmidt Camera. *The Telescope*, **5**, 6-10, 16, 1938.

[18] Smiley, Charles H. Flare in Schmidt Cameras. *Jnl. Opt. Soc. Am.*, **28**, 130-2, 1938.

[19] Cox, H. W. and L. A. The Construction of a Schmidt Camera. *Jnl. Brit. Astr. Assn.*, **48**, 308-313, 1938.

[20] Anonymous. The Schmidt Camera. *Observatory*, **61**, 156-9, 1938.

[21] Smiley, Charles H. The Remarkable Schmidt Camera. *Griffith Observer*, **2**, 92-5, 1938.

[22] Lower, Harold A. The Schmidt Astronomical Camera. *The Sky*, **2**, 8-9, 26, 1938

[23] Waland, R. L. Note on Figuring Schmidt Correcting Lenses. *Jnl. Sci. Instr.*, **15**, 339-340, 1938.

[24] Smiley, Charles H. A Note on the Schmidt Camera. *Jnl. Brit. Astr. Assn.*, **49**, 34-6, 1938.

[25] Linfoot, E. H. An Application of the Schmidt Principle to Microscopy. *Jnl. Sci. Instr.*, **15**, 405-6, 1938.

[26] DeVany, Arthur. A Rapid Method of Making a Schmidt Correcting Lens. *Pop. Astr.*, **47**, 197-200, 1939.

[27] Hendrix, D. O. An Extremely Fast Schmidt Camera. *Publ. Astr. Soc. Pac.*, **51**, 158-9, 1939.

[28] Wright, Franklin B. A Two-mirror Aplanatic Telescope with a Flat Field with Focal Plane in an Accessible Position. *Publ. Astr. Soc. Pac.*, **51**, 227, 1939.

[29] Cox, H. W. The Construction of Schmidt Cameras. *Jnl. Sci. Instr.*, **16**, 257-262, 1939.

[30] Hendrix, D. O. and Christie, W. H. Some Applications of the Schmidt Principle in Optical Design. *Sci. Am.*, **161**, 118-123, 1939.

[31] Thackeray, A. D. Schmidt Camera Types. *Observatory*, **62**, 242-3, 1939.

[32] Anonymous. A New Type of Astronomical Camera. *Telescope*, **6**, 136-8, 1939.

[33] Cox, H. W. and L. A. Further Notes on Schmidt Cameras. *Jnl. Brit. Astr. Assn.*, **50**, 61-8, 1939.

[34] Baker, James G. A Method of Making Aspherical Surfaces of Revolution by Means of Spherical Surfaces Alone. *Pop. Astr.*, **48**, 78-83, 1940.

LADD OBSERVATORY, BROWN UNIVERSITY,
PROVIDENCE, RHODE ISLAND, FEBRUARY 26, 1940.

Shadow Bands

By RICHARD L. FELDMAN

(PART III)

In Part II,* I presented the conclusions of G. Horn D'Arturo as to shadow band behavior based upon observations he had collected for the period from 1842 to 1924. The regularities which he had detected are practically identical with those the present writer reported in Part I (POPULAR ASTRONOMY, April, 1938), written before I had read D'Arturo's pamphlet; and my conclusions, based upon only eight isolated observations, were supported by the many reports from the January 24, 1925, eclipse and by most of the reports up to date; they were utilized in my successful predictions of band extension for the June eclipses of 1936 and 1937. The fact that the two of us who seem to have the most in-

*POPULAR ASTRONOMY, **48**, 2, 1940.

formation on bands, have independently reached the same conclusions as to the pattern of behavior, is a strong argument in favor of these conclusions.

That is as far as D'Arturo and I agree, however, as I pointed out. His pinhole image theory, the atmosphere providing the pinholes, is only one of a half-dozen ideas held by others, which I deem untenable. These ideas, and the names of some scientists known to be adherents, are summarized as follows:

Theory	Adherent
1. Real images from a stratum of vortices (or pinholes).	G. Horn D'Arturo, Ex-director, Astr. Obs., University of Bologna, Italy.
2. Unknown mechanism, perhaps like pinholes, disposed in conical shells, or envelopes, about cone-shaped shadow.	Frank H. Bigelow, Professor of Meteorology, U. S. Weather Bureau.
3. Refraction by air strata of different densities.	Chas. F. Brooks, Harvard; H. N. Russell, Princeton; Thos. D. Cope, Pennsylvania; Donald H. Menzel, Harvard; James Stokley, Buhl Planetarium.
4. Scintillation,—a refraction theory, described in "Physical Optics."	R. W. Wood, Johns Hopkins.
5. Diffraction bands.	Edward S. Holden, *U.S.S. Hartford* Expedition, 1883.
6. Diffraction, or at least some interference phenomenon, (*a*) as at edge of opaque object, or (*b*) by Lloyd's mirror effect.	The present writer.

Scintillation and Refraction

Authority today is almost as weighty as in the days of the ascendency of Aristotle. No theory, however attractive, and no investigator, however well informed, can expect an attentive hearing as long as so eminent an authority as Professor R. W. Wood stands across his path with his widely known text "Physical Optics." To clear the way for another view it is necessary that the insufficiency of Professor Wood's explanation, as carried in his book, be first shown.

The plane waves of light coming from the stars (and from the sun), Professor Wood says, are deformed by passage through striae of air of different densities, somewhat as when light is observed through a mixture of glycerine and water. The concave and convex portions of the deformed light wave produce concentrating and diverging effects, accounting for the alternate light and dark bands called shadow bands. In the case of the star, the light is too feeble to produce bands on the ground, but twinkling is described as another aspect of the same phenomenon. He says if we look towards a star with the eyes focused on a point five or six feet away, so as to get a double image, fluctuations in intensity of the two images will be detected, these changes being out of step with each other because one eye may be in a dark band while the other eye is in a light band.

He says that, whereas an image in a telescope of large aperture is not affected by scintillation, a reduction in the aperture by means of a diaphragm will cause it to appear. Since the light bands are due to concave wave-fronts, the focal point of the telescope will be found farther in and the change can be measured by moving the eyepiece until an occasional sharp image is obtained. Similarly, by withdrawing the eyepiece, the convex wave-fronts may be dealt with. Dr. Wood says that by this means he has measured the radius of curvature of these concave and convex light-wave fronts, obtaining values from 1800 meters to as high as 20,000 meters, with an average of about 6,000 meters.

On the other hand, scintillation is not observed in the case of planets, Dr. Wood says, because he conceives that the "shadow bands" produced by the light from one small part, are neutralized by the systems of bands produced by the light from the other parts of these heavenly bodies which have larger disks than the twinkling stars.

Criticism of Dr. Wood's Theory

We might begin by saying: If planets can produce enough systems to *prevent* shadow bands, why is the rim of the sun, during at least two minutes before and also after totality, incapable of setting up enough such systems to prevent the shadow bands so often prominently displayed? At two minutes before totality there may still be visible as much as one per cent of the sun's disc. Even one minute before, there may still be as much as 0.5 per cent (approx.) of the disc visible. In either case, the area of the sun sending light to the observer is many times as great as the disc of Venus, yet Dr. Wood holds that the larger the celestial area emitting light, the less the expectancy as to shadow bands.

However, the real objections to this scintillation theory are that it does not account (1) for the fact that the bands lie concentric with the lunar shadow's edge; nor (2) for the fact that the direction of progress before and after totality changes characteristically with respect to the edge of the shadow, as described in Parts I and II of this series.

Because of the weight attached to Dr. Wood's opinion on any branch of Light, I think I should add another word. In adducing evidence that the bands are closest together when nearest totality, D'Arturo gives, along with statements by Mannheim, Lockyer, Gillette, Thompson, Young, and Machado, a quotation from Wood: "Their distance apart varied so that it was at once apparent to me that no estimate of their width was of any scientific value whatever."[1] D'Arturo and I see in this the concrete statement that the bands varied in separation. The reader may also see a certain impatience on the part of the observer and a willingness to belittle or ignore the problem.

In acknowledging a statement from me on the subject, Dr. Wood wrote in 1936: "Shadow bands are well understood. They are purely

[1] *Publ. of the U. S. Nav. Obs.*, Sec. Ser., Vol. IV, App. I, D 115.

atmospheric. You will find them fully explained in my "Physical Optics" under Scintillation. I cannot understand why any eclipse expedition bothers to observe them (unless perhaps meteorologists who are interested in upper air currents). Fifty or more years ago someone advanced the theory that they were diffraction fringes, showing lamentable ignorance of diffraction theory. A narrow *self-luminous* source (such as the solar crescent) cannot give rise to fringes: Try to get them with a white-hot wire of filament (filament of wire?) if you doubt this."

In humorous contrast with this is the following paragraph from a letter received a few months later from a friendly professor of astrophysics: "Your theory that the bands are concentric with the shadow spot seems to me to be entirely reasonable. This would make them, at any point of observation, tangent to the 'crescent' of the almost covered sun at its brightest part, and would be consistent with the producion of bands parallel to a line source in the laboratory. (See R. W. Wood's "Physical Optics.")" (Note: Quotation ends *after* reference given.)

Wood's scintillation explanation might be classed as the special refraction theory. Among those holding to the general idea of refraction, three have expressed themselves in communications to this writer, Professor Russell to a news reporter, according to an article in the press at the time of the 1925 eclipse, and Professor Cope in a report to the American Astronomical Union of his observations at New Haven in 1925.

Regarding bands observed before totality at Ak Bulak, Siberia, on June 19, 1936, Dr. Menzel wrote me: "The sky was cloudless and we had excellent seeing conditions. I attribute the faintness of the shadow bands to this phenomenon. The intense shadow bands recorded in 1925 were undoubtedly due to the poor seeing conditions although their prominence was magnified because of the presence of snow. Although your suggestion regarding possible diffraction effects is interesting, I am inclined to believe that they arise wholly from atmospheric waves."

Dr. Stokley wrote in part, "it is much more reasonable to attribute them to regions of different density in the atmosphere."

In passing, I may mention briefly that Dr. Menzel's belief, as to the relation between seeing conditions and prominence of the bands, finds rebuttal in the statements of Rotch quoted in Part I, especially this: "They (the bands) were more prominent at high altitudes than at low levels." It must be conceded that the higher the altitude *generally* the *clearer the atmosphere overhead.*

Bigelow's Shells

The investigation by Frank H. Bigelow, Weather Bureau physicist, into the 1900 eclipse, has been recounted in Part I. He says: "We have thus far derived two facts to fasten the bands upon the images of the cusps as the origin of them: (1) Referred to the north and south line, the direction of the cusps and the shadow bands are generally parallel to each other, and (2) this direction varies distinctly between the

center of the path and the edge, yet keeping up the same parallelism during the local change between the cusps and the shadow bands. If these two geometrical facts are the correct result of this analysis of the observations, they are practically decisive in regard to the origin of the bands."

Basing his idea on the time for passage of the umbra in comparison with the duration of the bands, averaged (a questionable procedure) to 60 and 10 seconds respectively, he writes: "The shadow (1900) is nearly 50 miles in diameter, so that the medium which is favorable to the production of the shadow bands is one-fifth of 50 miles; that is about 10 miles in thickness. We are, therefore, brought to conceive of the umbra as surrounded by semi-opaque rings in the plane sections, perpendicular to the axis, of such a character that the crescents of the sun's disk will cast down images upon the ground through a flickering and wavy medium."

Elsewhere, "It must be admitted that there is some uncertainty, if not difficulty, in describing the exact action in the atmosphere close around the umbra shadow which should cause its edge to be surrounded by a semi-opaque medium such as we have likened to leaves of a tree." (The reference to leaves of a tree brings to mind the real images of D'Arturo.)

Diffraction Bands (1883)

Representative of another school of thought is a portion of the report of the *U.S.S. Hartford's* Expedition to the Caroline Islands for the eclipse of May 6, 1883. The heading is "Observation Of The Diffraction Bands." This portion of the report was prepared by Professor Edward S. Holden and addressed to Professor C. A. Young (famous predecessor of Professor H. N. Russell at Princeton), chairman of the eclipse committee of the National Academy of Sciences. No theorizing is included. It is fair to assume, however, that Professor Young, the other scientists on the expedition, and a reasonably large school of contemporary thought at that time believed the bands to be a diffraction effect. Points of interest in the report are the details of observation: Bands came at the rate of 80 per minute, duration 1¼ minutes, both before and after totality. From center to center, pre-totality bands measured 12 inches, post-totality 18 inches. This makes their speed (80 × 60 min. × 1 ft.) or 4800 ft./hr. before totality; and (80 × 60 × 1.5 ft.) or 7200 ft./hr. after totality; or about 0.9 and 1.3 miles/hr., respectively.

"The direction of motion of the bands before totality (N 60° E) was about 16½° to the east of the direction of that radius of the moon's shadow which passed through Caroline Island at second contact. The direction (N 92° W) after totality was only 2° to the west of the radius of the moon's shadow which passed through Caroline Island at third contact. It is possible that the first observations are erroneous by 16°, but I do not regard it as probable." (*Memoirs, Nat. Acad. of Sc.*, Vol. II.)

I have mentioned this report to show that formerly the diffraction ex-

planation was seriously entertained by responsible scientists. Bigelow states the case against diffraction in the following paragraph (eclipse of May 6, 1900): "The observers generally agreed that the motion was either slow or else indecisive in direction. Now, all this is quite positive against the diffraction theory of the origin of the shadow bands. The umbra on that view is surrounded by a fringe of diffraction bands disposed in circles around its center and necessarily borne along at the same speed as the shadow of the moon, since the diffraction phenomenon must be due, if it exists, to secondary waves formed at the edge of the moon, according to the usual physical principles. The shadow moved from New Orleans, Louisiana, to Norfolk, Virginia, about 1,000 miles, in 25 minutes Greenwich mean time, so that the rate is 40 miles per minute, or 2,400 miles per hour, which is equal to 3,500 feet per second. If they had any such velocities, the diffraction bands could by no means be detected by our observers, and certainly they could not be recorded as having velocities of only 6 feet per second, with a flickering, unsteady motion. Furthermore, the diffraction bands must, if they exist, consist of colored or spectrum fringes, but nothing of this kind has ever been detected. We therefore dismiss the diffraction theory from further consideration."

The present writer asks then, why should we not dismiss Bigelow's shells from our consideration? It is certainly unavoidable that such shells would have to travel at the same high speed as the diffraction effect, *as he pictures that effect in action.* Presence or absence of color with the bands is an aspect of the question which will take care of itself. The fallacy of Bigelow's comparison of the speed of the bands with the speed of the shadow-spot, grows out of use of the word "necessarily" above. Here we take departure from Bigelow and other critics to show that, far from a diffraction theory "necessarily" entailing a band speed of a thousand or two thousand miles per hour, it, on the contrary, can account for only such slow speeds as are actually reported, seldom running over 10 miles per hour, and occasionally stationary.

(To be concluded.)

Roosevelt High School, Washington, D. C., July 6, 1939.

Astronomy at the Palace of Discovery in Paris*

By ROBERT LENCEMENT

This article would have appeared much sooner had it not been for the circumstances which have for several months perturbed the activity of this side of the planet. I offer my apologies for this tardiness. The Palace of Discovery was closed at the beginning of hostilities, along with all the other Museums in Paris, and it was feared that this was its death sentence. In spite of all sorts of difficulties, it has been recently re-opened and the present public shows by its interest that we have done a wise thing. Let us hope that this can continue and thus aid in safeguarding the faith in the most noble of human conquests, a faith without which one would not know how to go about planning a better future.

I.

Created for the International Exposition of Paris in 1937, under the auspices of the Ministry of Commerce and of Industry, the Palace of Discovery was one of its most felicitous innovations. Its success exceeded the hopes of even the most optimistic, and in six months there were more than two and a half million visitors. Established for the short life of an exposition, the Palace was to disappear with it. The insistence of the public and the perseverance of its organizers obtained its provisional re-opening. The number of visitors exceeding sixty thousand during certain months has definitely proved that this organization answers a permanent need of curiosity and intellectual education which nothing up to this time had been able to satisfy.

The Palace of Discovery is not a museum where objects and precious instruments have been assembled in order to preserve them intact, and placed in that immobility which is the condition of their conservation. Rather, it is a vast and active laboratory. The apparatus which is to be found here is not meant for the curious of future generations. It is there to function, to be used before the visitors, or in their own hands, under the direction of Palace specialists. In each branch of science these instruments, even the rarest or most modern, function daily in the repetition of important and celebrated experiments which previously have had but rare witnesses. Naturally, the primary notions about each order of knowledge have not been neglected, and, in a general way, the visitor can gradually initiate himself in repeating the elementary experiments, and pass through all the steps which ultimately lead to a knowledge of the latest. All is presented in an orderly way, with the aid of illustrations, clear and concise sketches, and all the technique that can be of

*Translated from the French by Thomas D. Bowie, Carleton College, Northfield, Minnesota.

service to the educator: models, automatic instruments, the phonograph, silent and speaking films, and so forth. The Palace keeps in touch with new scientific discoveries as well as work in progress. It is in this way that the vastest monument which has ever been erected to the most precious of human activities—scientific research—leads man to the unveiling of the mystery of things.

Thus conceived, the Palace of Discovery interests everyone. For the curious, children, students, and men of science, there are at all times sixty demonstrators and lecturers to be found in the different rooms and laboratories, grouped by section: Mathematics, Astronomy, Physics, Chemistry, Biology, Medicine, Surgery, Micro-biology, etc. . . . These sections were organized under the direction of the elite of French scholars, who solicited the collaboration of all the countries in the world.

II.

The Astronomy Section was placed under the presidency of Professor Ernest Esclangon, member of the Institute of France, Director of the Observatories of Paris and Meudon.

Delegated by Professor Esclangon to study and organize this section in the beginning of 1936, I have remained in charge since that time. This work has been extremely interesting. For the first time in the world, there were the means to devote to the "Science of the Heavens" a vast exposition, for visitors of all kinds, and to learn from them the best ways to evoke and satisfy their curiosity. The success of this Section was and is very great. This success is due, in a large measure, to the novelty of modern astronomy to the public, and to its spectacular side which has been widely exploited. Education in France, so complete in all other branches of knowledge, gives little or no space to astronomy, above all to contemporary physical astronomy. Everybody knows a little physics, chemistry, or biology, with whose application to daily life everyone is familiar. But rare are the initiates to the Science of the Heavens—which is almost entirely new to the public and above all to the French public. Moreover, for the uninitiated, astronomy has the reputation of being inaccessible, like higher mathematics, and it is not uncommon to hear cultivated people say "it is much too difficult for me; I could never understand a thing about it." This seems to deprive them even of the desire to try; and the heavenly bodies continue to turn round and round, for them, in a profound mystery, intensely interesting, to be sure, but entirely out of their realm. Then astronomy becomes more of an article of faith than an exact science. People either admiringly believe all that the astronomers profess to have found out, or smile indulgently at them. Journalists rarely fail to cultivate these two tendencies in their readers, both of which are equally prejudicial to the dissemination of astronomical knowledge.

These considerations have guided the arrangement of the astronomy exhibits. It was tried above all to put aside the mathematical element,

the dry aspect of diagrams, pictures, etc., still remaining on rigorously scientific ground, far from all fantasy. The large development of knowledge of the universe in the last twenty or thirty years has been illustrated by the most striking documents. In a general way, photographs taken with telescopes, always small in the original prints, have been enlarged to the maximum permitted by the grain of the negatives, diapositives, and papers. It is somewhat paradoxical to illustrate astronomy, the science of the immense, on very small documents. A photograph such as the one of the moon or the spiral nebula taken with the Hooker telescope of Mount Wilson, which the visitor would have passed by without even noticing, becomes for him a veritable revelation when he sees it enlarged on several square meters, and presented under appropriate lighting. Each time that it has been possible, a model has been used to replace long and tedious pictures, sketches, and diagrams. Moreover, in general, visitors do not read abundant texts any more than they read explanations written in too-small letters. They much prefer verbal explanations of a lecturer who would be at their disposal in the halls.

Considering the instruments and experiments which are the basic material of the sections of physics and chemistry, for example, one easily understands how the astronomy section finds itself handicapped. It can not, like physics, perform its experiments, no matter where and at any time. It was difficult to install large instruments, almost incapable of being transported because of their construction, and which would not have been very efficacious under the Parisian sky. It is known, moreover, that it is difficult for more than two people at a time to look through a telescope, and that the uninitiated are always disappointed by the smallness of the telescopic images. They are astonished also, in not seeing, as in the photographs, the spirals with the richness of their details. Consequently, I had to limit myself to the installation in the sun room of a vertical lens, objective 33 cm, the light being supplied by a coelostat.

In fine weather this instrument projects an image of the sun, one meter in diameter, on an horizontal screen, visible to numerous persons at the same time. In the evening a double ocular makes it possible to show the moon and brilliant planets when there are not too many people. Finally, several lenses are arranged so as to simulate the telescopic vision of planets and multiple stars.

The great techniques and methods of modern astronomy which could not be directly demonstrated are more easily explained by the use of short films and commented on by a lecturer. For all the techniques that the astronomer uses, but which are more within the scope of other sciences, the visitors are sent to the halls of physics or chemistry where these subjects are amply treated. For example, light, optics, spectroscopics, the constitution of matter, etc. Finally, the historical side recalls the great steps which led to modern knowledge.

III.

If science in general knows no frontiers, it is all the more true of astronomy whose object of study is so unrelated to the boundaries that man has established on his planet. It would be impossible to conceive of a general exposition of the science of the stars which would be limited to its development in one country only. Thus the collaboration of all the observatories and institutions of the world was asked for, and the labels accompanying the exhibits, in indicating their origin, show that this call was widely answered. It is impossible to give here the list of institutions which have sent materials. Here is, simply, an alphabetical list of the countries represented in the section:

Austria	Belgium	Canada
Czechoslovakia	Egypt	England
France	Germany	Great Lebanon
Holland	Italy	Mexico
Norway	South Africa	Spain
Sweden	United States	U. S. S. R.

These documents, largely photographic, were carefully chosen as the most representative. It is hardly necessary to say that the American observatories, and in particular Mount Wilson Observatory, are widely represented. As I have said above, each photograph was reproduced either on paper or on diapositive. The largest paper prints measure 6x4 meters, and the largest diapositives one meter each side. These reproductions were all brought to the same density in order to obtain a homogeneous group. The only photographs which were not enlarged were the plates of *Amor* and *Anteros* discoveries sent by the Uccle Observatory (Belgium) and several planet photographs. Repetitions were avoided. The light for each object was studied with care and especially arranged in each room in order to obtain the best effects. Thus, the stellar universe room is in a general darkness where photographs under a slightly bluish light stand out. The whole gives an impression of night. The room next to it, on the contrary, the sun room, is well illuminated with white-yellowish light. In this room the diapositives of monochromatic negatives were colored in the wave-length of light in which they were taken.

The visit to the halls is facilitated by the order of presentation of subjects, either under the direction of a lecturer, or in following the directions of the catalog prepared for this purpose. All the objects are accompanied by a short text and a number referring to the catalog.

IV.

The Astronomy Section contains seven divisions:

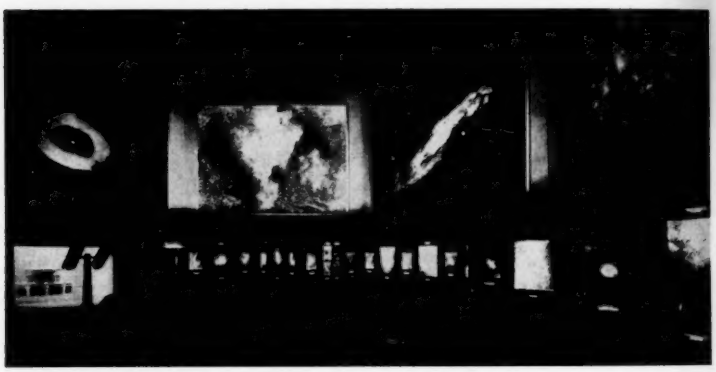
1. Stairway
2. Stellar Universe
3. Sun
4. Moon
5. Planets
6. Comets and Meteorites
7. Observatories and Instruments

The whole of this represents 1100 square meters of flooring; the walls

are used along 250 meters with a surface of 2000 square meters. The display material contains 350 photographs, 160 designs and pictures, 40 instruments and models.

1. *Stairway.* The astronomy section is reached by a large stairway surrounded on two sides by a balcony thirty meters long. In this hall are installed the objects which because of their dimensions could not be placed in the rooms. On the floor there is an orrery thirteen meters in diameter, including, with their movements all the bodies of the solar system whose diameter exceeds 1000 kilometers. On one of the sides of the balcony a panel twenty meters long illustrates with colored globes in relief, the stellar evolution. On the other side, a photographic reproduction of the northern Milky Way, twenty meters by four and a half, obtained through combining the twenty-nine negatives of M. de Kérolyr of the Paris Observatory Station at Forcalquier.

2. *The Stellar Universe.* This room, eighteen meters in diameter, contains the following divisions: stars, variable and novae, multiple stars, Milky Way, bright and dark nebulae, interstellar matter, and

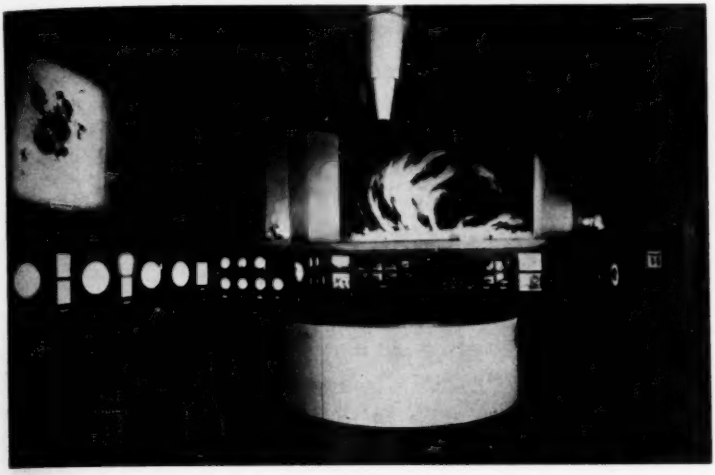


THE HALL OF THE STELLAR UNIVERSE

spirals. Eight large prints 6x4 meters are the reproduction of the negatives taken with the 100-inch telescope of Mount Wilson and the 83-cm telescope of the Paris Observatory Station at Forcalquier by M. de Kérolyr. A group of models with fluorescent colors illuminated with ultraviolet light illustrates the ancient conception of the universe and our present knowledge of the galaxy and of the spirals.

3. *The Sun.* M. d'Azambuja of the Meudon Observatory presided over the choice of the photographs for this room: surface, chromosphere, protuberances and eruptions, eclipses and corona, cycle of activity, and the terrestrial phenomena which are connected with it. In

this room is found the vertical lens which projects an image of the sun during the day. In connection with this, and to illustrate the two categories of the uneducated public of which I was speaking above—those who accept, without blinking, the most astonishing "discoveries" of the astronomer, and the hardened unbelievers—certain visitors would like



THE HALL OF THE SUN

to see the projected image of the sun when the sky is cloudy or when it rains and are disappointed that these people who "can look at the stars in the daytime" are not yet able to see through clouds. Others, on the contrary, do not want to believe that the image that lies before their eyes really is that of the "real sun."

4. *The Moon.* Among the best photographs of the Paris Observatory and the enlargements of the fine pictures from the large telescopes of Mount Wilson is found a tinted globe in relief—3 meters 48 cm in diameter (one one-millionth the size of the moon). The original of it was executed by Stuyvaert at the Uccle Observatory (Belgium) and up to this time there was only one copy of it, at the World Palace at Brussels. By means of projectors it is possible to represent on this globe the phases and variation of incidence of the sun's rays on the relief. To illustrate the dimensions of the smallest details visible on our satellite, a part of a photograph from Mount Wilson, the Archimedes region, was enlarged to the scale of one centimeter per kilometer. This would give for the totality of the lunar disk a diameter of thirty-five meters. That is going rather far in enlarging!

5. *Planets.* This room naturally includes many more sketches than photographs. These sketches are large-scale reproductions, colored

when necessary, of originals by some the best observers of planetary surfaces. (Fourbier, Antoniadi, Comas Sola, and others.) Accompanying this collection are movable globes and models. Among others there is a globe one meter in diameter executed by Mr. Antoniadi and including his observations of Mars, through an 83 cm. lens at the Meudon Observatory. The best planetary photographs (of Barnard, Slipher, Wright, and others) make possible all useful comparisons. Each planet occupies a vast panel.

A place is reserved for the earth with photographs taken from the stratosphere on the Explorer II of the earth's surface, and a globe showing the planetary aspect of the earth, executed by The National Meteorological Office of Paris. A section of the globe illustrates the present hypotheses of the internal constitution of our planet.

6. *Comets and Meteorites.* Mr. Baldet, of the Meudon Observatory has chosen for this room, in addition to the details of cometary heads and tails, a series of diapositives on the transformations of the Morehouse Comet, presented under the title: "The Story of a Comet." On the other hand, there have been assembled side by side the documents on meteors, trails and explosions, and meteorites. The fine samples sent by Dr. H. H. Nininger are placed next to the specimens of the Paris Museum.

7. *Observatories and Instruments.* A plan of distribution of observatories on the earth's surface is accompanied by photographs of the most celebrated and most characteristic instruments, and by models of observatories. Exact models of the first lens of Galileo and of the Newton telescope are compared with photographs of the Yerkes lens and the Hooker telescope. Several time pieces and a clock similar to that of the Paris Observatory complete this part of the section which was not possible to develop to a large extent.

During the Exposition, I had reserved a little room for "Astronautics" and to the problems brought up by proposed interplanetary voyages.

A collection of films, which, I hope, will be enriched little by little, includes along with films made to illustrate certain theories or methods (cosmogony, Cepheids, double stars, etc.) the rare direct astronomical films (McMath and Hulbert, Lyot, etc.). These films are projected in the section rooms during lectures, or in the cinema room of the Palace.

V.

During the year 1938 a temporary exposition of the Carnegie Institution of Washington provided a happy complement to the astronomy section in documents and models on recent research: interstellar matter, solar eruptions and their magnetic and radioelectric effects. Such temporary expositions permit the treatment of subjects which could not be permanently shown in halls, to develop certain others, or to show new work.

The Palace of Discovery, installed to last six months, is in its third year of activity. Since the closing of the Exposition of 1937, it is under the direction of the Ministry of National Education. The hospitality received at the Great Elysian Fields Palace and certain of its arrangements can hardly last much longer. It should be established in a special building, now in course of construction, where it will profit from the experience acquired since its opening. The astronomy section will continue to occupy an important place, with numerous improvements, for example a center of documentation and an observatory conceived specially for collective observation. Perhaps some day I shall have the occasion to describe it to the readers of POPULAR ASTRONOMY. As for its present form, and in spite of its weaknesses, which are disappearing one by one, astronomy at the Palace of Discovery constitutes a collection unique to this very day, interesting at the same time the average visitor for its spectacular side, as well as the initiate, by its rare or recent documents. It shows that the oldest of sciences is and will always be the youngest, and that this powerful instrument of culture and intellectual satisfaction can, better than any other, enlarge man's scope of knowledge.

PARIS, DECEMBER, 1939.

The Cleveland "Star Party"

By JAMES L. RUSSELL

David Dietz, the Science Editor of the Scripps-Howard newspapers, with his office in Cleveland, conceived the idea of putting on a "Star Party" for the public. Due to the great interest in the planet Mars, created by its recent close approach, he thought it would be an opportune time to really test the popular interest in the subject of astronomy. So Mr. Dietz consulted the writer, who is a local attorney, and Vice-President of the Cleveland Astronomical Society, and presented the proposition. The idea appealed to the writer and it was decided to carry out the project. Mr. Dietz was to arrange for the publicity in his column and through his newspaper, and the writer was to scout the town for telescopes of all kinds, and have them all at an appointed place on an appointed night.

Mr. Dietz immediately began running his publicity items, a little stronger each day, announcing that the Cleveland Press and the Cleveland Astronomical Society were having a joint "Star Party" at Edgewater Park on Thursday evening, the 10th of August. If clouds interfered, then it would be the next evening. On the day of the party, his newspaper printed a front page article, including a sky map of the constellations, urging the public to come and bring this sky map with them. It was also announced that the constellations would be pointed out, and the wonders of the sky explained.

In the meantime the writer got busy on the telephone, and, through

our membership, lined up all the telescopes belonging to amateurs and all the other telescopes he could find that could conveniently be transported to the park. The response was gratifying. The following telescopes appeared:

Two — long-focus 6-inch reflectors
Two — RRF short-focus reflectors
One — 8-inch long-focus reflector
One — RRF 10-inch short-focus reflector
One — 2½-inch refractor
One — 2-inch refractor
One — 3-inch refractor
One — 4½-inch refractor.

So, we had a motley assortment to show nearly everything in the sky.

The park is located on the shore of Lake Erie, with the lake to the north. The park is large, and had a large lawn of perhaps ten acres, used for symphony concert crowds. But, alas, it was surrounded with large street lights.

On the afternoon of the appointed day, the writer and Mr. Dietz went to the park and met the representatives of the park department and the police department, who were there by previous appointment. The park department agreed to turn out the lights for us, which was quite a departure from their normal activity, and the police department agreed to send us two loads of officers to keep the crowd in order. As to the difficulties that might arise they could not give us any information, for they had had no previous experience. Perhaps the crowd, if any, would push the instruments over, perhaps they would even get into arguments and maybe fisticuffs among themselves over the relative merits of the celestial objects. Perhaps they would even take one look at the assortment of amateur telescopes and go home. Perhaps even not come at all. However, we were promised an assortment of uniformed officers.

The park department was kind enough to send us a truck with some men to put up some ropes if needed. We looked over the field, and decided to place our telescopes on the north side of the field, near the shore of the lake, where it would be darkest, and where we could get a good view of the southern sky. The park department drove some iron stakes for us, and arranged the rope so that we would have four aisles or lanes, and could put three telescopes in each lane. This would allow the people to form in a line to the south and advance on the first telescope, which would be focused on Mars, let us say, then take a look and pass on to the next one, which would be focused on Epsilon Lyrae, and have the double star explained to them by the attendant. Then he or she would pass on to the next telescope which would perhaps be on Jupiter, or on a nebula. Each attendant in turn would explain what was seen.

Everything was in readiness, and the writer came early with his 10-inch reflector to set it up, and perhaps wait for the first patron, if anyone should be interested in astronomy. This was about 7:00 P.M., and the sun was still in the sky. Instead of having to use the telescope to find the first patron, the writer nearly had to fight his way inside the ropes

amidst the anxious and curious crowd of perhaps 300 men, women, and children. The minute the telescope was spied, there was a rush for it, and it was lucky for the writer that some of the Cleveland Braves had arrived for our protection. The crowd was not in any way boisterous, but curious, and each one pressed to have his question answered before we could even see the stars, and before the telescope was even out of the automobile. Of course, the writer did his best, and we assured the people that every question would be answered in due time.

Well, to make a long story short, the people arrived in droves and squads. By dark, there were several thousand people in four long lines, facing the roped lanes. It was necessary for each telescope attendant to have two or three more attendants assigned to him to keep the people from running against the tripods, getting the gadgets caught in their clothes, and tipping the telescopes over, or grabbing the eyepiece with a half-nelson in their anxiety to take a look. Of course, everyone wanted to look at Mars, although it was, to say the least, not such a fine object in a short-focus reflector. So they looked, and looked, and went from one line to another and got a free glimpse of all the sky could show. When Jupiter came up over the trees about 11:00 P.M., all the telescopes were turned to it. We tried to explain that it was a much finer object to look at than Mars, but we had to keep several of the instruments on Mars just the same, for about half of the people insisted on seeing Mars, whether it was a fine looking object or not.

These long lines of people, estimated at 5,000, slowly approached the telescopes for their look. They would get restless. Mr. Dietz foresaw this, and arranged to have a loudspeaker unit installed on a post in the center of the field. It was the plan for Mr. Dietz to talk over the system about the wonders of the heavens and to have the writer stand in the middle of the field with a powerful flashlight, and point out the constellations and objects the announcer would call for. This was very successful, and the people would audibly express their admiration when some bright constellation was pointed out to them, and they understood. This also served to keep them occupied and contented during their long wait. This procedure was repeated about every half hour.

By the time the first hour was past, the lines were very orderly and patient. Pop vendors appeared as out of nowhere, and did a rushing business. Even the amateur astronomers themselves would gulp a bottle of pop between words of explanation, and point to the sky with a cracker-jack carton. Boxes were provided by the telescope owners and attendants for the children and the short people to stand on in order to get a look through the reflectors. The long ones had to bend a bit, and the short people had to stretch a bit; necks were twisted, eyes were strained, but everyone, man, woman, and child had a look. Women even brought their infants in arms, and in several instances, it was reported that the mother would insist that the infant "See that little star, honey, isn't that nice?" to the disgust of the attendant.

At midnight the lines were still long, and we thought it was going to be an all-night job, but by 1:30 A.M. the last enthusiast had looked, and the field, littered with pop bottles, cracker-jack boxes, and other debris, was deserted. Then the officers came in a group for their look. A good time was had by all, even by the amateur astronomers. Their feet were tired, their voices hoarse, but the response had been beyond all expectations. The telescopes were taken down, and taken home.

It was such a success that the "Press" wanted to conduct another party in a park on the other side of the city, and the night was set for a week later. Again nature provided us with a perfect night, and again an even greater crowd of 7,500 people came out. Again we worked until late, but this time, instead of putting three telescopes in each lane, we put one and had eleven or twelve lanes. In this way, the lines were not so long, and we were through by midnight.

A third "Party" was arranged for and conducted in still another section of the city, and again the response was beyond our expectations. Many came who had been to the previous party for another opportunity to see the wonders of the heavens. It seems as though everyone in the city of Cleveland was astronomically conscious. It was a revelation to everyone concerned to see the great popular interest in astronomy. The questions they would ask were not all foolish. So many people really wanted to know of these things, and did not come out because of mere curiosity.

This report is made with the hope that the spirit of it may be caught up in other communities, and perhaps a similar thing may be done in other cities, and thus the knowledge of astronomy be spread among the lay people.

AUGUST 25, 1939.

The Lunar Eclipse of October 28, 1939

By WALTER H. HAAS

Several decades ago the late W. H. Pickering found that a number of areas on the moon go through a regular cycle of changes each lunation. He suggested that these alterations were due to physical agencies, such as frost, clouds, and vegetation; but most astronomers have preferred to think that changes in the sun's illumination of the areas in question are sufficient explanation. Pickering pointed out that lunar eclipses afforded a test of his theory and that the sudden chilling of the moon at such times should affect areas whose changes were the effect of physical agencies. I have summarized the results of observations from 1898 to 1938 in an earlier paper.[1] As probable effects of the shadow's passage over the moon were found an enlarging of the bright spot around

[1] "The Effect of Lunar Eclipses on the Moon," Walter H. Haas, *P.A.*, 47, 373, 1939.

Linné, a fading of the south tip of the oval dark spot in Riccioli, and perhaps also a darkening of the Grimaldi floor.

At the eclipse of October 28, 1939, which was not quite total, the moon was in the umbra from 4:55 to 8:18, U.T.; and this eclipse could be seen well, weather permitting, all over the United States. Observations have been reported by the following amateurs (I myself encountered cloudy skies):

Observer and Station	Telescope	Magnification
Barcroft, Madera, California	6-inch reflector	144×
Beamer, Des Moines, Iowa	6-inch reflector	100×
Houston, Manhattan, Kansas	6-inch reflector	40×
Johnson, Des Moines, Iowa	8-inch reflector	213×
Smith, Smyer, Texas	8-inch reflector	180×
Vaughn, Des Moines, Iowa	3-inch reflector	150×

Seven different craters were watched, with the following results (all these craters contain periodically varying areas):

Aristarchus was unaffected, according to Smith and Barcroft. It was covered by the umbra from 5:02 to 7:27, U.T.

In Eratosthenes, both Smith and Johnson suspected that the dark areas in the east part of the floor were darkened. Barcroft saw no effect but is less experienced than either Smith or Johnson. Eratosthenes was covered from 5:19 to 7:40. At 8:50 Johnson thought that the dark areas had already regained their normal intensity.

In Grimaldi, Smith suspected a darkening of the floor; but Johnson, Barcroft, Beamer, and Vaughn did not see this effect. None of the observers noted any change in the bright spots along the west wall of Grimaldi, where a change had at one previous eclipse been alleged. Grimaldi was in the shadow from 5:13 to 7:08.

Macrobius was unaffected, according to Barcroft.

Johnson, Smith, and Barcroft agree on no changes in Messier or in Pickering; these twin-craterlets were in shadow from 5:54 to 8:03.

In Riccioli, Beamer suspected the gradual development of a lobe on the southeast side of the dark spot between 7:20 and 8:00, and Houston found the south tip missing sometime between 7:10 and 8:18. Johnson, Barcroft, Smith, and Vaughn found no changes. It is true that Houston's low power may have given him better contrast than was enjoyed by the other observers; but drawings by the various observers indicate that Johnson saw more than did the others, and in particular he saw and drew before the eclipse the aforementioned lobe and did not mention its absence or dimness when he observed Riccioli at 7:15. Any change appears unlikely. Riccioli was in shadow from 5:03 to 7:09.

Schickard was observed only by Vaughn, who thought that two dark areas on the floor grew darker and more extensive between 7:07 and 7:45. But since the latter aspect would be more nearly the normal one and since on October 30 Vaughn observed Schickard as resembling the 7:07 aspect, this suspected change appears unlikely. Schickard was covered by shadow from 5:43 to 6:54.

A set of photographs taken at the Griffith Observatory in Los Angeles indicates that Linné was probably larger and brighter at 8:45 than before the eclipse and perhaps confirms the change Vaughn suspected in Schickard but gives no evidence of progressive change in the other objects examined.

Recently Latimer J. Wilson of Nashville, Tennessee, forwarded to me a series of photographs which De Witt of that city took with a 12-inch reflector on the occasion of the lunar eclipse of July 16, 1935. These photographs indicate as effects of the shadow's passage a probable fading of the Grimaldi floor, a possible fading of the south tip of the Riccioli spot, a possible enlargement of the spot around Linné, a possible but unlikely darkening of the Schickard dark areas, and no effect on Eratosthenes or the dark area west of Webb.

The recent observations support the three conclusions stated tentatively in the previous paper:

1. Most areas, even when exhibiting periodic changes, are unaffected; and such effects as are produced are slight and of short duration.

2. It is more likely than not that there are some actual changes, some arrests or reversals of normal development.

3. The same object may be differently affected at different eclipses. Linné was much more enlarged in 1902 than at any other eclipse as yet observed; and the fading of the south tip of the Riccioli spot was pronounced on May 14, 1938.

Certainly this investigation ought to be continued at future eclipses, and attempts should be made to check results so far secured. Well-planned sequences of photographs can supply valuable data upon this problem. I shall welcome correspondence about this interesting subject.

Department of Mathematics, Ohio State University,
Columbus, Ohio, February 3, 1940.

Planet Notes for May, 1940

By R. S. ZUG

Note: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. The sun's apparent motion during May will carry it from the constellation Aries into the constellation Taurus, the transition date being May 20.

Moon. Phenomena of the moon will occur as follows:

		h	m
New Moon	May 7	12	7
First Quarter	14	20	51
Full Moon	21	13	33
Last Quarter	29	0	40

		h
Apogee	May 2	23
Perigee	18	19
Apogee	30	17

Mercury. Mercury will be a morning star, but too near the sun to be easily located, during the first part of May. The planet reaches superior conjunction May 21, after which it will be an evening star, but quite inconspicuous in the early evening sky.

Venus. Venus will be an evening star, and will attain its greatest brilliance on May 20. Tabulated numerical data of interest to observers are to be found on page 28 of POPULAR ASTRONOMY for January, 1940.

Mars. Mars will be an evening star during May. Its brightness and elongation from the sun are decreasing. The apparent motion of Mars is now eastward, and will carry the planet from Taurus into Gemini during May. By the end of May the planet will be situated not far from the third magnitude star, ϵ Geminorum.

Jupiter. Jupiter will be a morning star, and, by the end of May, will rise about two hours before the sun.

Saturn. Saturn also will be a morning star, and, during May, will be situated a few degrees to the east of Jupiter.

Uranus. Uranus will be in conjunction with the sun on May 12.

Neptune. Neptune is now well situated for early evening observers. The planet is in the constellation Virgo. A chart illustrating its apparent motion is to be found on page 31 of POPULAR ASTRONOMY for January, 1940.

Asteroid Notes

By HUGH S. RICE

Ceres is the best asteroid for small telescopes this spring. It circles about δ Leonis. On April 5 (0^h U.T.), it is 3° northwest of δ; on May 15, it is $2\frac{1}{2}$° west of δ; and on June 4, it is $1\frac{1}{2}$° northeast of θ Leonis, inside the triangle in eastern Leo. The magnitude on May 1, is 7.5.

Pallas is at the last of its visibility for this apparition. On April 9 (0^h U.T.), it is $5\frac{1}{2}$° south of Procyon, and on May 8, it is 3° west of δ Hydrae. The magnitude is also about 7.5.

Juno and Vesta at this time are not in a good position for observation.

The Coppernicus-Institut of Berlin-Dahlem has published its annual book of ephemerides of all the minor planets whose orbits are well known. The ephemeris of Ceres was computed by Dr. Rabe, and that of Pallas by Dr. Kahrstedt, both of the above-mentioned institute. There are now 1489 asteroids whose orbits are well enough known that elements and ephemerides can be computed.

Hayden Planetarium, American Museum of Natural History,
New York City, March 19, 1940.

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1940	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
May 11	41 H.^{3}Gem	6.0	23 58.6	—0.1	—3.4	155	0 40.4	—1.4	+0.1	232
14	60 Cnc	5.7	0 52.6	—1.0	—1.6	116	2 1.3	—0.8	—1.7	287
18	*f* Vir	5.9	1 3.1	—1.1	—1.4	148	2 8.3	—2.1	—0.1	265
19	*h* Vir	5.4	0 41.8	—0.6	—1.4	158	1 35.9	—2.2	+1.1	252
24	95 B.Sgr	5.8	2 31.2	..	..	22	2 53.0	..	..	342
30	14 Psc	6.0	6 19.3	—0.2	+1.6	86	7 22.6	—0.5	+2.0	234
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
May 11	BD+18°1112	6.4	1 48.4	—1.2	+0.9	39	2 18.6	+0.7	—3.6	339
11	124 H.^{3}Ori	5.7	3 13.2	—0.1	—0.6	67	3 59.0	+0.6	—1.8	309
14	60 Cnc	5.7	0 35.7	—1.2	—2.5	145	1 41.1	—2.0	—0.5	259
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
May 11	124 H.^{3}Ori	5.7	3 7.7	—0.6	—1.5	106	4 10.8	—0.3	—1.3	273
13	BD+14°1850	6.4	6 25.4	0.0	—1.4	111	7 19.3	+0.3	—1.2	281
14	κ Cnc	5.1	6 47.9	+0.1	—2.3	146	7 33.1	—0.1	—0.7	252
18	319 B.Vir	6.3	6 17.1	..	..	41	6 40.5	..	..	8
24	BD—18°5079	6.5	11 50.8	—2.0	—0.4	85	13 12.0	—1.4	—0.4	250

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Comet Notes

By G. VAN BIESBROECK

There are no known comets under observation at this time. The numerous objects that were visible at the end of last year have all become too faint or else are in too unfavorable geometric conditions. This applies especially to the two Periodic Comets Faye and Giacobini-Zinner which were found last fall and which should reach maximum brightness at this time theoretically. However, the angular separation from the sun proves too small to detect them in the twilight even in the very transparent sky of this mountain observatory.

Not until next summer are other periodic comets expected but the explorers of the sky always have a good chance to discover new ones in the meantime.

W. J. McDonald Observatory, Fort Davis, Texas, March 11, 1940.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

During the past year the necessity for preparing for publication Part 2, Vol. V, *Publications of the Flower Observatory,* on Double Stars, which has already appeared, and Part 3, Vol. V, on Variable Stars which is still in process of preparation, has taken up so much of my time left over from my routine duties that it has been very difficult to keep up properly with the work reported by the A.M.S. and get out Meteor Notes in a manner acceptable to myself. I can only assure our members that by the end of 1940 this condition should have been remedied and I hope to have more time from then on to devote to reductions of our work which would form the basis for these Notes. However, such is most certainly not the case at present, so I have to present what it is possible to prepare.

For many years the A.M.S. has been most kindly supplied by the Hydrographic Office, U.S.N., and by the U. S. Weather Bureau with copies of reports from officers of ships dealing with meteors. In fact, the Hydrographic Bulletin regularly prints a request outlining the type of report which is most useful and complete. At the end of each year I compare all these reports received during the previous twelve months and try to find observations of the same object from two or more ships. In 1939 there are two certain cases and one very questionable one. The two certain ones will be discussed here. The (abridged) reports are quoted:

(S1). "Second Officer R. J. Raymer, . . . Am. S.S. *H. D. Collier* . . . reports that at 0711 G.M.T. on Feb. 15, 1939, in Lat. 12° 18′ N, Long. 91° 25′ W. . . . a brilliant meteor . . . appeared above Spica at an altitude of 55°, bearing 127° (true), traveled downward in a straight line and disappeared slightly to right of the Southern Cross at an altitude of 19°, bearing 156° true, . . . visible at least 4 seconds . . . at least twice as bright as Venus . . . The trail . . . disappeared within a few seconds . . ."

(S2). "Second Officer W. F. Bentley . . . Am. S.S. *Kansan* . . . at 0710 on Feb. 25, 1939, in Lat. 12° 15′ N, Long. 91° 49′ W. . . . a brilliant white meteor . . . appeared about half way between . . . Arcturus and Spica, at an altitude of 50°, fell vertically, and disappeared at an altitude of about 10°, . . . visible about 2 seconds . . ."

On the basis of these two observations, the positions of the ships were plotted, the azimuth lines drawn, and, after corrections for curvature were applied to the altitudes, the heights of the beginning point and ending point were computed for each ship. Unfortunately, the azimuth for S2 is obviously uncertain by many degrees at least, so I merely measured off the coördinates from a large globe instead of computing it. Also the ships were so near together that small azimuth errors would largely affect the results. Using the azimuth mentioned as 280° (the bearing +180°), and measuring from the diagram with ruler where possible, we derive as heights; for S1: 50.6 and 6.0 km; for S2: 87.0 and 9.4 km, average 68.8 ± 18.2 and 7.7 ± 1.7 km.

To see what improvement could be made, the azimuths of 280° and 287°.5 were tried. These gave, in order, for S1: 41.2 and 5.2, for S2: 82.0 and 7.2, aver-

ages 61.6 ± 20.4 and 7.0 ± 2.0 km; and for S1: 79.5 and 8.5, for S2: 111.3 and 10.3, averages 95.4 ± 15.9 and 9.4 ± 0.9 km.

The one certain thing is the very low altitude of the end point, which all these solutions give as near 8 km. There is no way of certainly deciding which of the three altitudes of the beginning point is nearest the truth, but for various reasons I believe that the last and highest is best. Using this, we find the path 93 km long, geocentric velocity 31 km/sec, radiant at azimuth 287°.5, altitude 67°.5, which measured from the globe gives an approximate position of R.A. 193° and Decl. +6°.

In this case, an error of even a very few minutes of arc in the position of either ship would account for the uncertainties. It can only be hoped that navigators take the trouble to give as exact positions as possible for their ships as well as for the coördinates of the meteor's paths.

(S1). "Second Officer O. Skaug, . . . Panamanian motorship *Permian* . . . reports . . . at 0807 on Sept. 17, 1939, in Lat. 27° 45′ N, Long. 70° 48′W. . . . a meteor about 5 or 6 times the size of Mars . . . It appeared at an altitude of 35° (by sextant), bearing approximately 270°, traveled along an almost horizontal path showing a long tail of different colors, and disappeared bearing approximately 200°, having been visible 17 seconds . . ."

(S2). "Second Officer A. T. Wilson, . . . Am. S.S. *Yorkmar* . . . at 0806 on Sept. 17, 1939, in Lat. 25° 56′ N, Long. 73° 48′ W. . . . a meteor having a very unusual and lasting brilliance was observed. The body appeared directly under Polaris at an altitude of approximately 20°, traveled eastward slowly for 7 seconds until, under the constellation Gemini, at an approximate altitude of about 10°, it disappeared in . . . a terrific explosion. A light, greenish-hued trail was left . . . clearly visible for several seconds after the body had disappeared . . ."

The second case was handled in the same manner but leads to more perplexing results. Here the ships were so far apart that no small errors in their positions would be very important. The azimuth of "Gemini" from S2, however, could have been anywhere from 245° to 272°, hence this datum is doubtful; 258° was actually used. The solution gives for S1: 218 and 114 km, for S2: 77 and 48 km. Averages in such a case have no meaning! I made a few changes in the data to see if things could be improved. Only if the altitudes for S1 were decreased from 35° to 15° (an impossible error of observation but one that might have been made in recording) could any agreement be found. If this were done, the results are quite accordant and are, for S1: 68 and 45 km. Then the averages are 72 and 47 km, which are very reasonable. Due to the various uncertainties no radiant is computed. The one safe conclusion here is that the path was not very far from horizontal, and the long duration $(07 + 17)/2 = 12 \pm 5$ sec, is typical of that type. The two cases just discussed obviously show how necessary it is that most careful observations be made. It also illustrates the chances ships' officers have of contributing to science at the expense of such little effort, as the watch officer has to be on the lookout in any case. Doubtless both fireballs were seen from other ships whose officers were too indifferent to record them. One or two additional observations, in either case, would probably have sufficed to detect where the erroneous data were and therefore might have permitted the making of really good solutions.

1940 March 9, Flower Observatory, Upper Darby, Pennsylvania.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California, Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver

Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

The Distribution of the Recognized Meteorites of North America

By LINCOLN LA PAZ

[*Continued from the C.S.R.M. in the March issue.*]

§2. SUGGESTED CAUSES OF NON-RANDOM INFALL

The results of the last section make clear that the meteoritic concentration in the southern Appalachian area, A, is the one outstanding discrepancy between the observed distributions of meteorites in the subregions G, A, B, C of R and the distributions predicted by (2) for the individual subregions under the hypothesis H. We propose now to examine the competency of those agencies conjectured by Farrington to be responsible for this singular concentration of meteorites.

(α) *Obstructive Effects.*—According to G. von Niessl, meteorites in the terminal portions of their atmospheric trajectories have a motion quite like that of any other falling body, subject to only gravity and air resistance. There exists a considerable body of observational evidence and meteorite-penetration data supporting this view.[15] Of course the occasional occurrence of cylindrical meteorite-impact holes with axes considerably inclined to the vertical (*e.g.*, that of Knyahinya, Czechoslovakia), or showers of meteorites distributed over a roughly elliptical area, whose major axis coincides with the projection of the meteoritic velocity-vector on the surface of the earth,[16] shows that a meteorite may retain a horizontal component of velocity down to the point of impact. However, there is little doubt that in the great majority of cases the terminal, horizontal velocity-component is vanishingly small. It follows that the meteorites found in the southern Appalachian area were for the most part descending almost vertically in the end portions of their paths through the atmosphere and hence that the high mountains in the region A cannot have exercised upon the meteorites "obstructive effects" in the sense Farrington had in mind.

(β) *Magnetic Influences.*—Denote by O the center of the earth. The terrestrial magnetic field is very approximately that of a uniformly magnetized sphere, Z (with center at O), the radius of which may be taken as unity. At external points ($r \geqslant 1$) the field due to such a sphere is identical with that produced by a suitable magnetic doublet, d, placed at the center, O, of the sphere, Z. Similarly, for $r \geqslant 1$, the gravitational field due to the earth is equivalent to that which would be produced by a mass, m, equal to the mass of the earth, placed at the point O. Denote by $M(r)$ the force in dynes exerted by the magnetic field due to d on unit magnetic pole at distance r from O; by $G(r)$ the gravitational force in dynes exerted by m on one gram of mass at distance r from O. Then $M(r) = c \times r^{-3}$, $G(r) = k \times r^{-2}$, where c and k are constants. Hence, for all $r \geqslant 1$, $M(r)/G(r) =$

c/k. Now $c = M(1)$ is, at most, approximately 0.5 dyne, while $k = G(1)$ is about 980 dynes. Whence, for all $r \geqslant 1$, $M(r)/G(r) < 0.00052$. In view of the very small value of this ratio and the known magnetic characteristics of meteorites, it is apparent that an extraordinary local increase in the intensity of the earth's magnetic field would be necessary in order to give rise to a magnetic force in the Mt. Mitchell area even remotely comparable, in its attraction for meteorites, to that due to the normal gravitational field of the earth in this vicinity. Since the rather complete magnetic data available for the locality in question[17] indicate no such anomalous, local enhancement in the intensity of the earth's magnetic field, it follows that the meteoritic concentration observed in A is not the result of "magnetic influences."

(γ) *Gravitational Effects.*—As Farrington has himself already pointed out, calculations give no evidence that the gravitational attraction due to the elevated masses culminating in Mt. Mitchell is, by itself, competent to produce a local concentration of meteorites such as occurs in A. One might postulate next the existence of subcrustal mass anomalies producing what the geophysicist would describe as a pronounced gravitational "high" in this region. However, since the locality in question contains the highest summits in the Appalachians, the assumption of the existence of such subcrustal anomalies would be in direct contradiction to the theory of isostasy, according to which masses elevated above the general crustal level will be compensated for by a *defect in density* in the underlying material. Since the theory of isostasy seems to be universally accepted, although there is not as yet general agreement as regards the mechanism by means of which a state of (near) isostatic balance is achieved,[18] the assumption of such anomalies is definitely unacceptable.[19]

(δ) *Extra-gravitational Effects.*—Since Farrington has hinted at the possibility of the existence of extra-gravitational forces tending to bring about the concentration in question, it seems worth while to conclude this section with a test calculated to disprove the existence of any such forces without requiring actual knowledge of their nature. Unless we make the wholly unwarranted assumption that these unknown forces conjectured by Farrington to produce non-random infall over A ceased to operate when records of witnessed falls began, it is evident that they would have functioned to produce a non-random distribution of *observed* falls in this area. The number of such witnessed falls in A is $N_A(w) = 21$. If we employ (2), with $n = n_A$ and $N = N_A(w)$, we find the values of $\nu(j)$ exhibited in the first line of the following table:

TABLE 6

j	0	1	2	3	$\geqslant 4$
$\nu_c(j)$	1.	2.	2.4	1.8	1.9
$\nu_o(j)$	1.	2.	1.	3.	2.

The close agreement between these calculated values, $\nu_c(j)$, and the observed values, $\nu_o(j)$, in row No. 2 of Table 6, makes it most improbable that any force has acted to produce a non-random distribution of witnessed falls in A.

§3. The Probable Cause of the Southern Appalachian Meteoritic Concentration

In view of the failure of each of several different suggestions to furnish a satisfactory explanation of the meteoritic concentration existing in A, it may seem that the problem of ascertaining its cause is a recondite one. However, in the

writer's opinion, the solution of this question has heretofore been overlooked solely because of its obviousness! We recall first that results exhibited in Table 6 at the end of §2 give us every reason to believe that, as far as *witnessed* falls are concerned, the distribution of recognized meteorites in A is essentially the result of chance. The meteoritic concentration in question appears to owe its origin, therefore, to the unusually large number of *finds* of iron meteorites made in a certain subregion of A, *viz.*, the Farrington circle, F. This observation immediately raises the question: Have conditions for the discovery and preservation of iron meteorites of unwitnessed fall been more favorable in the Farrington circle, F, than in the region R as a whole and the portion of A exterior to F in particular? It appears that this question must be answered in the affirmative for the following reason: not only was the southern Appalachian region one of the first penetrated and settled by the English and Scotch pioneers but it contains widely disseminated auriferous deposits which were discovered and worked by white men earlier than any other gold field in the United States[20] and which have been the site of more or less continuous activity for approximately a century and a half.[21] This fact in itself would not necessarily imply that the discovery of a large number of meteorites is to be expected in A, for California, which in the course of a half-century produced far more gold than can be credited to the entire Appalachian area, is not notable for the number of meteorites found within its boundaries.[22] The really significant thing about the Appalachian field is that, within it, gold has been won to an unprecedented extent by *small-scale placering*, done with the pan, "*batea*," and those simple forms of rockers,[23] the operation of which is essentially a panning process on a larger scale.[24] The manipulation of such devices for the recovery of gold necessitates, as the writer has ascertained by personal experience, the handling and close inspection of almost all of the considerable volume of "pay-dirt" and gravel treated. On the contrary, large-scale operations, particularly those of hydraulic and dredging type, minimize the amount of personal contact which the miner has with the materials he "washes out" and hence greatly reduce his chances of discovering meteorites. It is a most depressing experience for the meteoriticist to make an estimate of the number of imposing meteorites which have been exhumed in the course of those hydraulic operations in which entire hills were washed away and then, unrecognized, have been buried beyond hope of recovery beneath prodigious heaps of tailings or mountainous stacks of boulders! In the Appalachian placers, on the other hand, while a stony meteorite might have been cast aside as only another one of the innumerable host of rocks impeding the recovery of the precious metal, it is to be expected that the unusual weight of the irons and iron-stones and especially their evident metallic nature would have at once aroused the enduring interest of the hand-miner ever on the alert for the appearance of rich ore-masses such as those, the discovery of which led to the development of the southern Appalachian field. This remark applies with equal force to the case of iron meteorites uncovered in the widespread and intensive agricultural activities carried on by the population of A, either concurrently with or as a substitute for placer mining.[25] Conditions definitely favorable to the discovery and preservation of iron and iron-stone meteorites seem, therefore, to have existed in A.[26]

Several tests of the accuracy of the conclusion just stated at once suggest themselves: In the *first* place, the ratio of found irons and iron-stones to all finds should be somewhat larger in A than in R taken as a whole, for in subregions of R of considerable extent the surface occurrence of "rocks" of any kind is unusual

enough to lead at once to their close examination,[27] while the deep soil-mantle of precisely these subregions is such as to favor the penetration of the denser siderites and siderolites to levels below plow-depth and therefore beyond discovery. In the *second* place (since for States in *A* containing auriferous deposits of equal extent and richness, the quantities of gold recovered may be taken as roughly proportional to the amounts of prospecting and placering done), in spite of all the uncertainties which attach to records of both gold and meteorite discoveries, there should be some rough concordance between the numbers of meteorites recognized in the various States of *A* and the sums of gold (chiefly placer) credited to the individual States. In the *third* place, the meteorites found in *A* should exhibit a concentration in and around the gold-bearing subregions of *A*.

It is easy to make the *first* test on the basis of data collated by Farrington in his *Catalogue*.[28] One finds that 97% of all *finds* in *A* are irons or iron-stones, while the same fact is true of only 88% of all finds in *R*. This difference is in the right direction and is as large as could reasonably be expected. To make the *second* test, we draw up the following tabular comparison between the numbers of recognized meteorites and the amounts of precious metal recovered in the various gold-bearing States in *A*:

TABLE 7

	e	*n*	*m*
Virginia	3.2	5.	—
North Carolina	21.7	14.	12.
South Carolina	3.6	4.	—
Georgia-Alabama	16.5	13.	6.1
Maryland	0.05	2.	—
Tennessee	0.2	13.	—

In Table 7, *e* is the total amount of gold *estimated* to have been recovered between 1799 and 1896;[29] *n* is the number of meteorites found in the interval 1799-1896;[30] and *m* is the amount of gold *known* to have been "actually deposited at the United States assay offices and the Mint . . ." between 1799 and 1896.[31] The unit for *e* and for *m* is $1,000,000. In the preceding tabulation, Alabama and Georgia are treated as a single unit for the following reasons:

(*A*). The Cherokee Nation (to its great misfortune) originally occupied much of the gold belt of Georgia and Alabama. The United States Government was obliged by its various treaties with the Cherokee Nation at least formally to prohibit whites from entering into and mining within the Cherokee country. On occasion these treaty obligations were enforced by Government troops, *e.g.*, during the turbulence accompanying the indefensible expulsion of the Cherokees from their lands (1831-38). As a result, gold was not discovered (or, at least, its discovery was not reported) in Georgia and Alabama until 1829-30, long after it was first found in Virginia (1782), North Carolina (1793), and South Carolina (1776?). Furthermore, fear of Federal prosecution for trespass into Indian territory seems to have led miners in Alabama to conceal the exact source of the gold they recovered. Thus, not a single grain of gold, *declared to have been found in Alabama,* is recorded at any United States mint or assay office before 1840 (shortly after the expulsion of the Cherokees had been completed), although the Alabama field was opened up at the same time (1830) as the Georgia field, peak production in both was reached between 1830 and 1840, and in this interval large sums of gold from areas in Georgia, where mining had become legitimate, were declared and deposited in Federal mints.

(*B*). Gold statistics for Alabama (possibly because of the facts just set forth) are palpably incomplete and misleading. Thus, in 1892, W. B. Phillips[32] states, "Of the yield of gold, there is no record, or indeed of anything in connection with the matter except that, at such-and-such localities, large numbers of men were engaged in the work and that at certain places it was said to be profitable." Becker in 1896 supported Phillips' view. The old records referred to by Phillips indicate that the placering operations carried on in Alabama were as continuous and extensive and therefore, presumably, as remunerative, as those of the adjacent Georgian field from which amounts in excess of $400,000 were recovered sometimes in a single year. Under these circumstances, one hesitates to accept the *estimate* made by Cramer in 1892 that the total amount of gold recovered in Alabama between 1799 and 1892 amounted to only a little over $400,000, while for the same interval he credits Georgia with approximately $16,000,000 and Tennessee, which has auriferous deposits trivial in size and importance as compared to those found in Alabama, with $166,000. These discrepancies are due probably to the fact that, for reasons suggested in (*A*), *ante*, a great deal of Alabama gold, undeclared as such, came into the conveniently located United States branch mint at Dahlonega, Georgia, or, declared as Georgia gold, was turned into other Federal repositories.

In Table 7, Maryland and Tennessee, containing gold-bearing regions of approximately equal extent, are grouped together as States very poor in gold as compared with the States in the upper bracket, a fact discovered, however, only after prospecting which was almost as prolonged and intensive as that carried on in the richer States. If the groupings described previously are accepted as justifiable, then the proportionality between the total number of meteorites found and the total amount of gold recovered is quite satisfactory. Thus, for the States in the upper bracket, one may say, roughly, *that for each million dollars' worth of gold recovered, one meteorite was found.* (To a person having first-hand knowledge of the huge amount of material which must be treated to win even a few dollars' worth of gold, nothing could emphasize more forcibly the actual *scarcity* of meteorites even where they are apparently most abundant!) For the States in the lower bracket, the corresponding relation is *one meteorite for each $15,000 to $25,000 worth of gold recovered.* This result is to be interpreted, of course, not as implying that Maryland and Tennessee are richer in meteorites, but rather as implying that they are much poorer in gold than the States in the upper bracket.

The *third* test suggested previously can be made by use of detailed maps of the southern Appalachian gold-fields prepared by the various State Geological Surveys[33] and the United States Bureau of Mines.[34] Examination of such maps discloses that although the area of the Farrington circle, *F*, is less than 54% of the area of *A*, yet it contains 89% of all recognized meteorites and more than 95% of all the placer fields in the entire region *A*. Equally significant is a composite map showing the areal distribution of finds and placers. Such a map is given in Fig. 1, *ante*. In this figure, each place of find of a meteorite is indicated by a symbol, + (or by a symbol, ‡, if the find was one of witnessed fall), while the small circles and the ellipses and long, narrow, closed contours shown in northern Georgia represent the approximate boundaries of the most intensively worked placer areas according to Yeates,[21] and Jackson and Knaebel.[34] The location of the circles and the orientation of the elongated contours clearly show that the richer auriferous deposits in *A* occur within a wide, irregular band trending with the Appalachian chain, southwestward from Virginia into Alabama. The importance of such trends in ore-bearing deposits is well known to miners. As soon as these trends are dis-

covered, they serve to govern the course of future systematic prospecting. According to Nitze and Wilkens,[21] the approximate boundary of the region disclosed by such prospecting to be gold-bearing is the contour *M*. Many of the deposits found in *M* are, of course, too poor to be profitably worked, but this fact was discovered only by actual sampling which involved the sort of hand-mining that we have reason to believe tends to promote the discovery of iron and iron-stone meteorites.

Possibly the most striking feature shown by Fig. 1, *ante*, is the singular absence of recognized meteorites in the region *L* of *F*, below the irregular southeastern boundary of *M*. Only 2 meteorites, both witnessed falls, occur in *L*. In connection with the question of the Carolina "Bays," attention has already been directed to this apparently inexplicable dearth of meteorites in *L*. If placer mining and the concomitant farming activities of the miners are chiefly responsible for the recovery of meteorites in *A*, then, in view of the well-defined eastern boundary early established for the gold deposits in *A*, this dearth can be regarded no longer as inexplicable. The next feature to impress one is an unmistakable concentration of meteorites of unwitnessed fall within the boundaries of *M*. Although the area of that part of *M* in *F* is only about 33% of the area of *F*, 34 (or over 51%) of the 66 such meteorites in *F* occur in this subregion of *M*. At first glance, the large number of meteorites of unwitnessed fall, *viz.*, 32, lying in the region *N* of *F* above the northwestern boundary of *M*, may seem inconsistent with the view that the discovery of meteorites is promoted by mining and its concomitant activities. However, if we recall that much of the region *N* was settled as a result of the migration of the inhabitants of *M* and that these inhabitants were either actually seeking new gold fields as the old ones in the east "petered out" or were at least "metal-conscious," we are led to expect that, because of systematic or sporadic prospecting, a considerable number of metallic meteorites will have been found in this region. This expectation is fulfilled by the data in Table 8, which exhibit the activities resulting in the discovery of the 32 meteorites of unwitnessed fall in *N*.

TABLE 8

	m	*p*	*a*	?
Alabama	0	0	2	1
Tennessee	7	1	1	3
Kentucky	2	4	0	5
Ohio	0	0	1	2
West Virginia ...	2	0	0	0
Virginia	0	0	0	1

In the first column is listed the number of meteorites definitely stated to have been recognized as a result of prospecting activities. In the second column appears the number of meteorites definitely stated to have been plowed up. In the third column is given the number of meteorites found in any other *specified* manner and in the fourth column is contained the number of meteorites of which nothing is known in regard to the mode of discovery. Table 8 shows that over one-third of the meteorites in *N* were recognized as a result of mining activities. The mode of discovery of another third of the meteorites in *N* is unknown. It is probable that a considerable number of these meteorites, as well as certain of the meteorites reported to have been plowed up (*e.g.*, Babb's Mill, Greene County, found on the edge of the eastern Tennessee gold-field), were found actually by prospectors in the course of either mining operations or concomitant agricultural activities.[85] The large number of finds in *N* cannot be regarded, therefore, as in conflict with evidence earlier presented.

In view of the satisfactory manner in which the suggested explanation of the

southern Appalachian meteoritic concentration has stood up under the various tests herein applied, there would seem to be some reason for the belief that the true (if prosaic) cause of the supposedly mysterious phenomenon in question has been found.

NOTES AND REFERENCES

[15] *Cf., e.g.,* Heide, F., *Kleine Meteoritenkunde,* 12-20, Berlin, 1934.

[16] For an instructive account of the action of air resistance in practically annihilating the original cosmic velocity of meteorites and in producing the phenomena observed in the meteoritic showers, see Spencer, L. J., *Min. Mag.,* **24**, 447-50, 1937.

[17] See, in this connection, Hazard, D. L., *U. S. Magnetic Tables and Magnetic Charts for 1915, Special Pub. No. 44, U. S. C. & G. S.,* Washington, 1917; *The Earth's Magnetism, U. S. C. & G. S., Ser. No. 313,* Washington, 1925.

[18] *Cf.* Jeffreys, H., *The Earth,* 2nd Ed., Chap. XI, Cambridge, 1929.

[19] Such gravity measurements as are available for the southern Appalachians give no evidence of the existence of such anomalies. Consult Bowie, William, *Special Pub. No. 40,* 1917, and *No. 99,* 1924, *U. S. C. & G. S.,* Washington.

[20] Jefferson, T., in his *Notes on Virginia,* 1782, makes reference to the discovery of a nugget containing 17 dwts. of gold, 4 miles below the falls of the Rappahannock. A 17-lb. nugget was discovered on the Reed plantation in Cabarrus County, North Carolina, in 1799.

[21] See Becker, G. F., *Gold Fields of the Southern Appalachians, Sixteenth Ann. Rep., U. S. G. S.,* 251-319, 1894; Yeates, W. S., *Gold Deposits of Georgia, Bull. No. 4-A, Geol. Survey Ga.,* 1896; Nitze, H. B. C., and Hanna, G. B., *Gold Deposits of North Carolina, Bull. No. 3, N. C. Geol. Survey,* 1896; Nitze, H. B. C., and Wilkens, H. A. J., *Gold Mining in North Carolina and Adjacent South Appalachian Regions, Bull. No. 10, N. C. Geol. Survey,* 1897. A rich gold strike in *A* was reported in 1939.

[22] However, it is probably not without significance that 5 of the 6 meteorites recognized in California by Farrington are either definitely stated to have been found by gold-miners or were discovered in placer regions! [The total number of meteoritic falls in California, known to date, is 11.—ED.]

[23] For an account of the primitive but ingenious split-tree rockers long in use by the "poor whites" of the Appalachian gold fields, see T. W. Swoyer, *Engin. and Mining Jour.,* **134**, 16, 1933. See also Nitze and Wilkens, *l.c.,* ref .No. 21, *ante,* pp. 30 *et sqq.*

[24] Examination of the mining literature cited in ref. No. 21, *ante,* will disclose a variety of reasons for the unusual amount of *small-scale placering* carried on in the southern Appalachians. We mention the following: (1) the richness of the gravel deposits in which the greater part of the easily recoverable gold of the region was contained; (2) the poverty of most of the early miners, which on the one hand rendered it impossible for them to finance large-scale sluicing, hydraulicking, or dredging operations and on the other hand made of the women and children, as well as the men, alert and expert hand-miners, trained almost from infancy in the use of the pan; (3) the occurrence of innumerable gold-bearing quartz veins, too small to be worked on any regular mining scale but paying 75c to $1.50 per day to the native miners who eagerly hunted out the richer streaks, crushed the quartz by pounding it with rocks, and panned out the gold. According to Nitze and Hanna, the vast majority of the gold veins were worked by such hand methods.

[25] The following quotation from Nitze and Wilkens (*l.c.,* ref. No. 21, *ante,* p. 29) will give an indication of the extent to which the miners of the southern Appalachian region were also farmers: "In these early days farming and gold-digging went, in many cases, hand in hand; and this is indeed still true, to some extent, at the present day. When the crops were laid by, the slaves and farm hands were turned into the creek-bottoms, thus utilizing their time during the dull seasons. Where mining proved more profitable than planting, the former superseded the latter entirely. Thus, in speaking of the Tinder Flats placer in Louisa County, Virginia, Silliman says: 'Jenkins is in the habit of substituting a fall working in the gold, for which he obtains $1000 annually, as a compensation for his tobacco crop, which he relinquishes in favor of the gold.'"

[26] Contrast Wylie, *l.c.*, ref. No. 6, *ante*, p. 141 or p. 411, respectively.

[27] Precisely this fact has been held to account for the large number of stony meteorites discovered in Kansas, a State with remarkably rock-free soil.

[28] *Mem. Nat. Acad. Sci.*, **13**, 1915.

[29] The values of e are taken from a table prepared by Cramer, S. W., and published in the production report of the Director of the U. S. Mint for 1892. Cramer's estimates, which were accepted and quoted by Yeates (1896)[21] and by Nitze and Wilkens (1897),[21] require an appraisal of the amount of bullion shipped to England, sold to local jewelers, or coined by the Carolina firm of the Bechtlers.

[30] According to Farrington.

[31] The value for m for North Carolina is based on data given by Hanna, G. B., *Geology of North Carolina*, **2**, 233, Raleigh, 1893, and official U. S. Mint reports quoted by Becker. The value of m given for Georgia-Alabama is certainly too small, since it represents merely the total coinage at the Dahlonega, Georgia, branch mint, while an appreciable, but undetermined, fraction of the gold mined in Georgia and Alabama went to the mints in New Orleans and Philadelphia. *Cf.* Yeates, *l.c.*, ref. No. 21, *ante*, pp. 30-1.

[32] *Geol. Survey Ala., Bull. No. 3*, 10, 1892.

[33] See Yeates, *l.c.*, ref. No. 21, *ante*, p. 32; Nitze and Wilkens, *l.c.*, ref. No. 21, *ante*, p. 12.

[34] Consult, Jackson, C. F., and Knaebel, J. B., *Small-Scale Placer Mining Methods, I. C. No. 6611, U. S. Bur. Mines*, 1934.

[35] *Cf.* ref. No. 25, *ante*.

[*Concluded.*]

References to Abstracts of Four Papers Read at the Seventh Annual Meeting

In *Bull. Geol. Soc. Am.*, **50**, No. 12, Pt. 2, Dec. 1, 1939, at pp. 1975, 1991, 1992, and 1993, are contained brief abstracts of the following four papers read in the joint sessions of the Society and Sections E and D of the A.A.A.S., held on the mornings of December 29 and 30, 1939, at the Seventh Annual Meeting in Columbus, Ohio (*v.* the "Report" and the "Program of the Seventh Annual Meeting" in the March, 1940, issue): Nos. 5 (Boon & Albritton's), 7 (Watson's), 20 (Watson's), and 4 (Wilson's).

Dr. L. La Paz Appointed Councilor

In accordance with Art. 3, Sect. 8, of the *Constitution*, as adopted at the Seventh Annual Meeting in December, 1939, the Council of the Society, on the nomination of its Executive Committee, has, under date of 1940 March 4, appointed Dr. Lincoln La Paz, of the Department of Mathematics, Ohio State University, Columbus, to fill, for the remainder of the 1937-41 term, a vacancy that existed among the Councilors. Dr. La Paz was already the Representative of the Society in the Council of the A.A.A.S., having been appointed to that position immediately after the Society was granted affiliation status in the Association (*C.S.R.M.*, **2**, No. 2, 94-5; *P. A.*, **47**, 157-8, 1939). Art. 3, Sect. 3, of the *By-Laws* (also as adopted at the last meeting) reads:

"Some member of the Council [of the Society], who is a fellow of the A.A.A.S., shall, on nomination by the Executive Committee of the Council of the Society, be appointed by that Council as the Representative of the Society in the Council of the A.A.A.S."

Dr. La Paz was, then, the logical choice for the vacant councilorship.

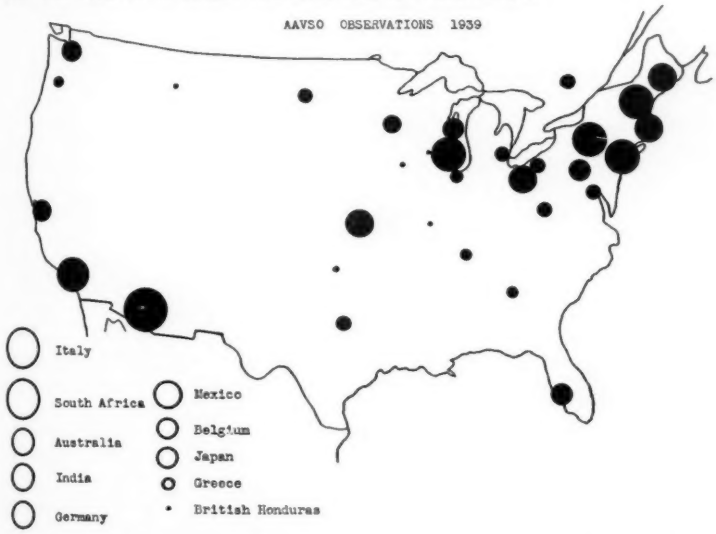
ROBERT W. WEBB, *Secretary*

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Distribution of A.A.V.S.O. Observations in 1939: A grand total of 54,655 observations by 142 observers was communicated to the Association headquarters during the year ending November 1, 1939. Of these, 20,000 were made by 31 observers in foreign countries, while the 111 observers in the United States reported a total of 34,655. Of the foreign countries Italy supplied 5,521, communicated by three observers: all but 37 were made by Eppe Loreta of Bologna. South Africa came next with 5,337 observations by five observers. Then followed Australia with 2,180 observations by three observers; India, 2,169 by two observers; Germany, 1,337, practically the work of one observer, Paul Ahnert of Berlin-Babelsberg; Mexico 1,316 by three observers; Japan, 790 by five observers; Belgium, 618 by Felix de Roy; Canada, 396 by two observers; and Greece, 327 by four observers. One observer in British Honduras sent in 9 observations.



If the United States is divided into two sections, east and west of the Mississippi, we find that there were 83 observers located in the eastern section with observations totalling 22,561, and 28 observers in the western section with observations totalling 12,094. W. L. Holt of Maine and Arizona observed in both sections.

The group-observing of the Milwaukee Astronomical Society deserves particular attention. This group, consisting of eighteen members using the 13-inch reflector, the mirror of which is on loan from the A.A.V.S.O., accumulated a total of 3,212 estimates of stars, many of them requiring special attention.

There were eighteen top-ranking observers in the Association: one in the 5,500 class, one in the 3,700 class, four in the 2,000 to 3,000 class, three in the 1,500 to 2,000 class, and nine in the 1,000 to 1,500 class. These eighteen observers contributed sixty-five per cent of all the observations reported. The remaining observers, 124 in number, sent in 19,164 estimates of magnitude, an average of 65 each. One half of all the observers who participated in the program contributed less than 100 estimates each.

The value of even a few sporadic observations should not be lost sight of, however. It is especially high when casual observers are fortunate enough to catch a star like U Geminorum or SS Aurigae on the rapid rise to maximum.

The American Association of Variable Star Observers has indeed become an international organization with observers in eleven foreign countries, widely distributed in latitude as well as in longitude. The distribution in longitude is especally valuable when observations of a particular variable star are required throughout a twenty-four hour interval.

The accompanying diagram, kindly prepared by Walter Houston, illustrates the distribution of observers and the number of observations in the different localities.

Spectral Changes for Cepheid Variables: A valuable addition to our knowledge of spectral changes in Cepheid variables, first investigated on a large scale by Dr. Shapley in 1916, when he presented the results of his studies on twenty of these stars, has been brought to our attention with the recent study of the spectral changes for thirty Cepheids by Margaret Walton Mayall and Mary Howe Baker. These investigators have determined the change in spectral type throughout the period for each variable discussed—mainly stars located in the southern hemisphere—and have confirmed previous conclusions that, in general, spectral variations follow the light variations remarkably well, earlier type spectra occurring near maximum light and later type, near minimum.

Means of the spectral observations were taken for each tenth of the period; and in general the complete range in variation averaged one spectral class, usually between F5.5 and G6.5. The periods for the stars under discussion ranged from $0^d.452$ to $38^d.750$, with an average period around 9.5 days.

Comparative curves are given showing spectral and light variations, and in many cases corresponding velocity curves. Whereas the similarity in shape between spectral curves and the light curves is strong for a majority of the variables examined, there are still some striking dissimilarities. If anything, there is a tendency for the spectral curves to be more flattened at maximum phase than for the light curve. Also the spectral change from maximum to minimum is, in some instances, slower than the corresponding change in magnitude. Perhaps more extensive observational material may alter these particular curves to some extent.

There appears to be a fairly definite correlation between spectral range and magnitude range. Four of the stars, however, deviate widely and, to bring them into conformity, either the spectral range would have to be lessened or the magnitude range increased. The correlation indicates a direct relation between range of light variation and spectral variation; that is, classical Cepheids with small range in magnitude have a correspondingly small range in spectral variation.

A very definite correlation is shown for the period—median-spectrum relation, well confirming previous deductions concerning these stars: those with the longer periods have the later type spectra.

The Mayall-Baker paper may be considered one of the most important investi-

gations of spectral variations in classical Cepheids made in recent years.

A New Be Spectrum-type Variable Star: To the already somewhat lengthy list of variables with early-type (Be) emission spectra is to added a very interesting and remarkable star recently discovered by Dr. E. Hertzsprung, director of the Leiden Observatory, who has requested that its variation be further investigated at Harvard. Accordingly Dr. Dorrit Hoffleit has undertaken an examination of Harvard plates covering the past fifty years.

The star, 101959 (—55°2154 in the Cape Photographic Catalogue), is situated only three degrees from the center of the Eta Carinae nebula. Dr. Hoffleit reports that since 1889 only two maxima have been observed, although recent observations indicate that the star is approaching a third maximum. The completeness of the observations precludes the possibility that another maximum could have occurred during this time-interval.

The range in brightness is between magnitude 8.2 and 9.6, and the variations are so slow that all the estimates of a single season can be combined into one mean point of the light curve. The first observed maximum had a duration of four years whereas the second extended over eight years. The intervals between successive rises to maximum were fifteen and thirty years, respectively. The rise to the first maximum was relatively rapid; the rise to the second, decidedly slow. Both observed maxima were flat, the descent to minimum fairly uniform in both instances, and the minimum brightness exceptionally constant, between magnitudes 9.5 and 9.6. The full account of this star will be published in *Harvard Bulletin* 913.

The light curve of the new variable star has striking resemblance to that recently observed for Gamma Cassiopeiae. Both stars are near or in nebulosity; the brightness of both varies slowly at and following maximum; both have about the same range in light variation and both are classed as Be stars, although Gamma Cassiopeiae has many additional spectral characteristics not identified so far in the spectrum of the recently discovered variable.

The new Hertzsprung variable should be ideal for observers in the southern hemisphere. An estimate of brightness once or twice a month should suffice to establish the form of the light curve. As has been remarked, the variable should now be continuing the increase in brightness shown by the observations from June, 1938, to July, 1939, when the last available photographic observation was secured.

Erratum: In the February, 1940, issue of these notes, page 95, for *Masses are 9.2 and 16.4*, read *Masses are 16.4 and 9.5.*

Observers and Observations Received during February, 1940:

Observer	Var.	Obs.	Observer	Var.	Obs.
Albrecht	24	32	Gregory	16	16
Baldwin	84	133	Griffin	25	38
Ball, A. R.	5	5	Guthrie	1	1
Ball, J.	28	35	Halbach	26	26
Ballhaussen	6	6	Harris	36	47
Blunck	9	9	Hartmann	118	145
Bouton	34	39	Holmes	5	5
Brocchi	13	33	Holt	130	390
Cilley	28	52	Houston	87	285
Cousins	28	51	Irland	6	8
Dafter	6	20	Jones	38	75
Diedrich	9	11	Kanda	2	8
Ensor	27	27	Kearons	55	107
Escalante	70	103	Kelly	19	32
Ferguson	1	1	Klaine	1	1
Fernald	67	41	de Kock	61	215

Observer	Var.	Obs.	Observer	Var.	Obs.
Kozawa	11	18	Ryder	3	3
Lovinus	6	6	Saxon	9	9
Lundquist	36	120	Schoenke	7	10
Maupome	29	35	Sill	27	27
McDevitt	19	23	Smith, F. P.	8	8
McPherson	20	20	Topham	55	55
Monnig	8	8	Treadwell	12	12
Moore	10	10	Walton	6	16
Palo	24	70	Webb	22	22
Peltier	21	65	Weber	25	37
Prinslow	6	8	Williams	11	43
Purdy	14	20	Yamada	8	21
Rense	42	50	Yamasaki	24	24
Rosebrugh	13	85			
de Roy	15	73	Total		2895

March 15, 1940.

Notes from Amateurs

The New Haven Amateur Astronomical Society

The February meeting of the New Haven Amateur Astronomical Society was held as usual in the Yale Observatory, at which Professor Ellsworth Huntington of Yale University addressed the society on "The Influence of the Sun upon the Earth." He stated that life, both animal and vegetable, was influenced by the variations in the sun's condition, the most common and obvious changing condition being the sunspots, which are tremendous cyclones of disturbances on the sun and occur in eleven year cycles. These disturbances of released and expanding pressure are accompanied by intense magnetic fields. The spots come in pairs with opposite polarity. Their vortical motions are in opposite directions and they keep their polarity through two complete cycles (22 years) then change their polarity. These powerful magnetic fields cause magnetic storms which we experience on the earth.

The variable effect of the sun is quite complex—weather averages are not the thing to look at as we are continually having droughts and extreme cold greatly exceeding long time averages of change of climate. In other words, the weather is uncertain, but these changes and even the uncertainties are thought to be directly connected with the changes in the sun. Certain things are changing on the earth in direct keeping with changes on the sun as for instance the compass needle, the aurora, radio reception, etc.

When sunspots are active we receive more ultra-violet light. It is difficult to measure the amount of ultra-violet light coming to the earth from the sun as in the stratosphere, more than 20 miles above the earth's surface, the short waves are absorbed by the oxygen of the upper air and at an altitude of 12 to 20 miles the ozone absorbs more light of short wave-lengths.

The Chinese in the 14th century recorded observing sunspots and from some of these ancient records of observations much valuable information has been obtained.

Professor Huntington himself has traveled extensively and has done much research on this historic problem of sunspots. By his own close examination of some 350 Sequoia tree rings in California, he has been able to compare wet and dry

periods of many years ago as indicated by the width and growth of these rings with early records of sunspot cycles. He finds, for example, in the 14th century that the levels of water of inland seas and lakes show evidence of a close agreement between high levels and active sunspots.

The thickness of clay deposits in Colorado and Nevada and even in New England also show evidence of the short 11-year sunspot cycles, and of longer cycles which perhaps are connected with solar changes.

Coming back to the present time, he clarified some apparently contradictory evidence as to solar changes and their effect on the earth's atmosphere by citing instances when the "lag" between an apparently delayed action brought about terrestrial conditions which seemed to be months or years later than the solar cause which produced them but which were actually in accord with known changes in the sun.

He explained the weather effect upon the mind and physical condition of man, stating that according to his own investigations and observations the death rate was greater the day preceding a storm and averaged less following a storm.

Professor Huntington's talk was most interesting and instructive and was appreciated by his audience.

F. R. BURNHAM, *Secretary.*

March 12, 1940.

Amateur Astronomers Eclipse Expedition

The Amateur Astronomers Association with headquarters at The American Museum of Natural History has made detailed plans which will enable its members and others to witness the annular eclipse of the sun on April 7. The party is to leave New York City just after noon on Saturday, April 6, and return to New York City just after noon on Monday, April 8. The destination of the train is Jacksonville, Florida, which is within twenty-five miles of the central line. It is hoped that an airplane will be available for observing the eclipse above the clouds in the event of a cloudy sky. It will be possible to join this party at Philadelphia, Baltimore, Richmond or at intermediate points.

Amateur Astronomical Society Activities

Announcements from three amateur astronomical societies have recently come to the office of POPULAR ASTRONOMY which indicate renewed activity in these societies for the current season.

The Rittenhouse Astronomical Society of Philadelphia, which because of its long history and its list of distinguished members might be regarded by some as a professional society, is nevertheless regarded by its newly elected president, Mr. Arthur E. Bassett, as "fundamentally of, by, and for amateurs." He promises interesting meetings and urges attendance upon them on the part of members and friends, and also solicits suggestions from the members for making the Society even more significant than it has been in the past.

The Eastbay Astronomical Association, in its *Bulletin* for February, calls attention to the fact that the celluloid model of the 200-inch telescope, which was on exhibition at the Golden Gate International Exposition is now at the Chabot Observatory, the headquarters of this Association. The *Bulletin* also describes several other features of interest to the members who are in reach of the Chabot Observatory in Oakland, the center of amateur astronomical activity in that region.

The Milwaukee Astronomical Society has issued a sheaf of six mimeographed pages which is entitled "Astronomical Observing Guide for the Year 1940." In-

formation is given concerning the location and administration of the observatory which is owned and operated by this Society. Also the schedule and character of the meetings of the Society are described. Also astronomical events which are to occur are listed by months so that amateurs may be informed as to what phenomena they may expect and possibly observe. From a statement by the compiler of this material, it seems that an adequate number of those sheets is at hand and are intended for free distribution to those interested.

Yakima Amateur Astronomers

The regular monthly meeting of the Yakima Amateur Astronomers, Yakima, Washington, was held on March 5. The unusual clustering of the planets in the evening sky was the central subject for the meeting. As a bit of instructive entertainment a game entitled "Scrambled Astronomy" was indulged in. Following are a few items of this game:

Rearrange the letters grouped in the left-hand column to form the words, the meanings of which are given in the corresponding position in the right-hand column.

LLEAYH	English astronomer who first predicted the return of a comet, and after whom one of the most famous of all comets is named.
SCREEHUL	The constellation towards which the sun, and with it the entire solar system, is moving through space.
DINARTA	The point in the sky from which (due to an effect of perspective) the meteors of a meteor shower seem to emanate.
XONIQUE	Time of the year when daytime equals the night in length all over the globe.
STUUCARR	The star whose light was harnessed a few years ago so that it turned on the illumination of the World's Fair in Chicago.

The Cleveland Astronomical Society

One of our best meetings was held at the Warner and Swasey Observatory, Friday, March 8, at 8:00 P.M. Dr. S. W. McCuskey lectured on "Interstellar Matter." He presented a fine collection of slides showing in a graphic manner the structure of the galactic system. He brought forward in a clear manner the number and distribution of spiral nebulae in interstellar space—also giving a comprehensive idea of the part played by cosmic matter of a very diffuse nature. His lecture was an inspiration to all of us. He has the rare gift of transmitting his own clear thinking to the audience. On view at the observatory was the architect's drawing of the new and greater observatory which we hope will be ready this fall. The great dome will house a Schmidt type telescope—a product of the Warner and Swasey works. Dr. Nassau discussed our coming dinner meeting which will be held the last part of April. At the dedication of the new observatory he hopes to have a program that will bring astronomers both professional and amateur to Cleveland. Russel brought a fine 12-inch mirror of short focus which he had just finished. It will be incorporated in a Schmidt telescope on the mounting which he is now constructing. With the new facilities soon available we expect a large increase in membership. Prospective members can get information from Margaret Parkin, Secretary-Treasurer, The Cleveland Club, Cleveland, Ohio.

Euclid Beach Park, Cleveland, Ohio. DON H. JOHNSTON.

Law of Planetary Separations

From certain publications[1] that have appeared recently in England, one is led to the belief that no serious attempt has been made, so far, to replace Bode's law by some other law that will embrace the whole of the planetary system.

Astronomers, surely, must have found very little interest in the problem for otherwise they could not have failed to discover the new law; the very law that we are submitting below for their consideration.

As is well known, Bode's law breaks down for Neptune, and if it does include Mercury it does so by vitiating the geometrical progression (ratio 2) on which it is based.

The pure geometrical progression, of course, still holds good but nature has confined its rule within certain limits, limits outside which another rule appears to reign supreme, that is, the arithmetical progression.

The new law might be stated thus:

In going from Venus to Uranus the distances expressed in astronomical units between the planets in order form the geometrical progression .3, .6, 1.2, 2.4, 4.8, 9.6, whereas inside the orbit of Venus and outside the orbit of Uranus the intervals are equal to the extreme terms of this progression.

In other words, the distances of the planets from Mercury are in arithmetical, geometrical, and arithmetical progression, the progressions overlapping at either end. See also note at foot of Table I (The planetary system).

Tables II, III, and IV, show that the new law, appropriately applied, will govern the satellite systems as well. Here again, as with the planetary system, the progression that dominates the field is the arithmetical one.

TABLE I

THE PLANETARY SYSTEM

	In Astronomical Units			
	Actual mean distances from Mercury	Actual intervals between planets	Adopted intervals according to progressions	Computed mean distances from Mercury
Mercury	0	.....	.....	0
		.33	.30	
Venus	.33	.....	.....	.30
		.28	.30	
Earth	.61	.....	.....	.60
		.52	.60	
Mars	1.13	.....	.....	1.20
		1.28	1.20	
Asteroids	2.41	.....	.....	2.40
		2.40	2.40	
Jupiter	4.81	.....	.....	4.80
		4.34	4.80	
Saturn	9.15	.....	.....	9.60
		9.65	9.60	
Uranus	18.80	.....	.....	19.20
		10.88	9.60	
Neptune	29.68	.....	.....	28.80
		9.49	9.60	
Pluto	(39.17)	.....	.....	38.40
?			9.60	
		.....	.....	

The first three numbers in the last column form an *arithmetical* progression;

[1] *Nature*, Vol. 141, p. 245 (February 5, 1938); *Nature*, Vol. 142, p. 670 (October 8, 1938).

the second to eighth, inclusive, a *geometrical* progression; the last four again an *arithmetical* progression.

The overlapping of the progressions might, naturally, be dispensed with, and the law proposed modified accordingly, but it is not considered advisable to do so for the following two reasons. First, because the overlapping provides what is believed to be a better link for the progressions, and secondly, because, by reducing the middle region, we deprive the original geometrical progression of two of its terms unnecessarily.

TABLE II

JUPITER'S SATELLITE SYSTEM

	In Equatorial Radii			
	Actual mean distances from Satellite V	Actual intervals between satellites	Adopted intervals according to progressions	Computed mean distances from Satellite V
V	0	.....	.....	0
		3.36	3.35	
I	3.36	.....	.....	3.35
		3.50	3.35	
II	6.86	.....	.....	6.70
		5.60	6.70	
III	12.46	.....	.....	13.40
		11.38	13.40	
IV	23.84	.....	.....	26.80
			26.80	
Missing			.....	53.60
			53.60	
Missing			.....	107.20
(158.06) VI } 160.06			53.60	
(162.06) VII } (mean)			.....	160.80
			53.60	
Missing			.....	214.40
			53.60	
Missing			.....	268.00
(327.46) VIII } 331.46			53.60	
(335.46) IX } (mean)			.....	321.60
			53.60	
?			.....	
			53.60	
?			.....	

Here the first three again form an *arithmetical* progression; the second to seventh, inclusive, a *geometrical* progression; the last six an *arithmetical* one.

The intervals between the satellites VI and VII, and VIII and IX, being too small for the regions they are in, we regard these tiny satellites in the light of the asteroids among the planets and group them as shown.

TABLE III

SATURN'S SATELLITE SYSTEM

	In Equatorial Radii			
	Actual mean distances from Mimas	Actual intervals between satellites	Adopted intervals according to progressions	Computed mean distances from Mimas
Mimas	0	.....	.....	0
		0.88	0.90	
Enceladus	0.88	.....	.....	0.90
		0.95	0.90	
Tethys	1.83	.....	.....	1.80
		1.39	1.80	
Dione	3.22	.....	.....	3.60
		2.51	3.60	
Rhea	5.73	.....	.....	7.20
		11.64	7.20	

TABLE III—CONTINUED

	Actual mean distances from Mimas	Actual intervals between satellites	Adopted intervals according to progressions	Computed mean distances from Mimas
Titan	17.37	.....	.....	14.40
		4.34	14.40	
Hyperion	21.71	.....	.....	28.80
		34.86	28.80	
Iapetus	56.57	.....	.....	57.60
			57.60	
Missing			.....	115.20
			57.60	
Missing			.....	172.80
			57.60	
Phoebe	213.69	.....	.....	230.60
			57.60	
?			.....	

Here, as in the preceding instances, the first three, the second to ninth, inclusive, and the last four form an *arithmetical*, a *geometrical*, and an *arithmetical* progression, respectively.

Of all the satellite systems (the planetary included) Saturn's is the only one that comprises three bodies with exceptionally large discrepancies; Rhea, Titan, and Hyperion. It is worthy of note, however, that just as the larger discrepancies here are those on either side of Titan, the giant, so with the planetary system, the larger ones are those on either side of Jupiter; although much smaller in comparison.

TABLE IV

URANUS' SATELLITE SYSTEM

In Equatorial Radii

	Actual mean distances from primary	Actual intervals between satellites	Adopted intervals according to progressions	Computed mean distances from primary	
Missing			.....	4.35	(0)
			0.75		
Missing			.....	5.10	(0.75)
			0.75		
Missing			.....	5.85	(1.50)
			1.50		
Ariel	7.35	.....	.....	7.35	(3.00)
		2.85	3.00		
Umbriel	10.20	.....	.....	10.35	(6.00)
		6.60	6.00		
Titania	16.80	.....	.....	16.35	(12.00)
		5.60	6.00		
Oberon	22.40	.....	.....	22.35	(18.00)
			6.00		
?			.....		

As will readily be seen, the problem here admits of more than one solution and we are only indicating what we consider to be the more probable. For clearness' sake, we give in this table the distances from the primary. The distances from the missing innermost satellite are shown at the right in parentheses. These show that the first three are in *arithmetical* progression, the second to sixth, inclusive, in *geometrical* progression, and the last three in *arithmetical* progression.

Note: The values used in the tables have all been borrowed from Russell-Dugan-Stewart's Astronomy; the only exception being that of Pluto. The mean distance of the asteroids was taken from the text of the book.

E. VOILAS.

7, Melika Farida, Cairo, Egypt.

An Astronomical Relationship

The most significant scientific discoveries are those that do not seem to fit into the accepted scheme of things, because they alone point the way toward new and different truths. The dangerous rut of orthodoxy is just as real for scientists as for those engaged in any other organized effort, and escape from its confining walls is fully as difficult. It is for this reason that such puzzling phenomena as the origin of cosmic rays, and the different paths that light and radio waves follow on the surface of the earth, should be warmly welcomed to the consciousness of the true scientist.

I have discovered another such item to offer for consideration.

If the apparent periods of eastward revolution of the heavenly bodies around the earth are considered in connection with the number of times the earth rotates during one apparent revolution of the sun, a peculiar and possibly highly significant relationship is found to exist.

The equinoxes are taken as fixed reference points in the heavens, and the sidereal period of revolution of any body is the time required for that body to move 360° in relation to the equinoxes. Thus the period of the earth is one sidereal day, or 0.002738 years, and the period of the sun is one year.

We will designate the number of sidereal days in a year divided by 1000, or 0.3662422, as U, and the period of revolution of each body in years as P, and find the following equation

$$y = \frac{\log P}{U} + 7$$

where y is a quantity which we will call the space number of the body concerned, for lack of a better term. The common logarithm to the base 10 of the period P is used.

The space number y appears to have a fundamental cosmic importance, because of its regularity for the different heavenly bodies. The earth is zero, the moon 4, the sun 7, Mars 8, the asteroids 9, Jupiter 10, Saturn 11, Uranus 12, Neptune 13, and the outermost planet, Pluto, is 13.5. It even includes the stars as a group, when their period of eastward revolution in relation to the equinoxes is considered. The star space number is 19.

Another surprising thing is that Mercury and Venus, which to an earthly observer appear to revolve as satellites of the sun, rather than around the earth, and have no satellites of their own, do not fall regularly in the list.

The calculations resulting from this equation are listed in Table I. The actual

TABLE I

	Sidereal Period in Yrs. (P)	Space Number (y) — Actual	Space Number (y) — Nominal
Earth	0.002738	0.000	0
Moon	0.07480	3.925	4
Sun	1.0000	7.000	7
Mars	1.881	7.749	8
Asteroids	(4.716)	(8.839)	9
Jupiter	11.862	9.931	10
Saturn	29.458	11.012	11
Uranus	84.015	12.258	12
Neptune	164.788	13.058	13
Pluto	247.697	13.540	13.5
Stars	26,300.	19.05	19

space number is that calculated from the observed period P and the equation. It can be compared with the nominal space number in the last column.

It is seen that the calculated number in all instances is very close to the nominal, or whole number. There is a regular variation in the agreement extending from Mars, which is one-fourth unit low, to Uranus, which is one-fourth unit high; but when this is plotted it is seen to be so regular as to constitute merely a secondary structure within the primary series.

In the table the period of the asteroids is interpolated as being the mean value. The period of the stars is not yet known with great exactness, so that possibly if it were calculated from the exact space number of 19 the result would be as accurate as are the measurements we now have.

From a mathematical standpoint it is scarcely conceivable that this consistent and regular series arrangement could be the result of chance alone. Such a result indicates a deep-seated and fundamental cause, whose nature is still obscure. With its discovery we may hope to have achieved another important step in the process of combining the many diverse phenomena of nature into the one great truth signified by the word *universe*.

FRED C. BOND.

1645 S. 80th Street, West Allis, Wisconsin.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Are There Heavy Stars?

About the beginning of the century it was calculated that Sirius had about 3.13 times the mass of the sun, and its companion 0.4 that of its primary. Presumably this relation holds, but it is now stated that Sirius is 2.5 times as heavy as the sun while the companion is thought to be very tiny but extremely heavy. Thus Sirius is reduced somewhat in mass while the companion is so greatly reduced in size that it is, therefore, necessary that it have a specific gravity several thousand times greater than that of lead. Assuming this to be true some astronomers advanced the supposition that this companion star is made up of "stripped" atoms, atoms with all of their electrons driven off by great heat and pressure so that the nuclei settle closely together but yet retain their gravitational attraction. If this be so then we ought to be able to produce stripped atoms in our laboratories, though such heavy matter might drop through the producing apparatus like a bullet shot from a rifle. However, this companion star may itself be revolving about a heavy dark star, the combined mass of both being sufficient to account for the observed motion of Sirius. Indeed the difficulty of drawing an ellipse through the observed positions of the companion and its seemingly systematic deviation from such a curve seems to indicate that another body is involved. Or the companion may be a very large planet, with high albedo, rendered visible by the brilliant light of Sirius. It would thus show a spectrum similar to that of Sirius itself. Whether star or planet it may have a large satellite, which of course would be in-

visible to us. Estimates of the size of the companion may be too low just as estimates of the size of Sirius itself may be too high.

Like the measures of radial speeds of distant nebulae by spectroscopic means, whereby it seems that recessive speeds increase progressively with the distance, it is probable some progressive error inherent to interferometer measurements of diameter is leading us to believe that certain stars are unduly large or small. If distant stars are greatly expanded they would not likely be visible as stars. It is due to similar estimates of diameter that Algol and its eclipsing companion are assumed to be more tenuous than cloud yet Algol is visible across the immense distance it is away. Perhaps the interferometer catches the extremities of the coronal streams or outlying masses of hydrogen, calcium or helium, driven out by the light rays from these hot stars or it may be that the waves in our own atmosphere render the interferometer more or less unreliable. It seems safer to assume a general uniformity of matter than to depend on unreliable measurements and to suppose that matter in certain cases must behave in an unique and freakish manner.

However, if true, it is highly interesting that by stripping from atoms their electrons the nuclei will then crowd so closely together that the gravitational effect is so greatly increased per volume. It would seem to show that gravitation is a function of the nucleus and not of the electrons and that it is not heat alone that keeps a star expanded. However, recognized authorities differ so widely on recent hypothetical speculation as well as to supposed masses, densities, and distances of various celestial bodies that we should not be stampeded by astonishing assertions.

Sirius is assigned a distance varying from 8.5 to 8.8 light years, the semi-axis major of the orbit of the companion is variously estimated at from 7.48 to 7.62 seconds of arc and its period of revolution from 48 to 52 years. After all corrections are allowed for, the companion does not follow a smooth curve. Therefore, whether these discrepancies are due to observational errors or other causes it is evident that a small angle must make a great difference in actual distance of the companion from Sirius at 8.6 light years distance from the earth.

If the companion is a small dense body made up of stripped nuclei we must suppose this mass to be shielded in some way from a supply of electrons else it must again expand to become like known forms of matter. Perhaps when we are certain that light and gravitational energy consist of the emission of nuclear particles or of dissociated electrons instead of merely waves we might accept the idea of dense dwarf stars or planets not conforming to Eddington's mass-luminosity law. Perhaps even dense dark bodies may slowly radiate some sort of energy till the whole mass is dissipated into space as invisible energy.

W. E. Duckwall.

Hillsboro, Ohio.

The Black Sun

Away from the lights of the city, in the silence of a winter's evening, we are watching the stars. It is the time when they are scattered most richly over the heavens; when they shine with the most piercing brilliancy. They seem to beckon to us to leave the turmoil of this world, and rise toward them. On the wings of fancy we journey through the vastnesses of space. Gradually as we approach star after star they change from tiny twinkling lights to mighty, burning, rolling suns. We see the worlds that circle around them, nourished by their light and heat. We see the beings who people the worlds. Some races have built such lofty civilizations that they live like gods. Others are toiling in the depths of degradation.

We begin to think about the immensity of space, and the immensity of time, and the immensity of the law that governs them both. Our thoughts overwhelm us. We realize how small is man. We are afraid. Awful thoughts crowd into our imagination. Death looms before us in his blackest form. Each of these suns and inhabited worlds must die. They cannot live forever. But, where are their corpses? Where are the dead suns? Where are the dead worlds? Surely they are not among the brilliant host which shines above us.

Space is filled with dark stars, which greatly outnumber the visible ones. They are suns which long since have ceased pouring forth light, heat, and energy. They tear through space unseen, carrying their cold lifeless planets with them. Of all the powers of the universe these are the most to be dreaded. We know that our Solar System is far separated from any living star; but we are ignorant whether or not we are in close proximity with some dark star. Only at the last moment shall we be able to tell, for when it is almost upon us, it will suddenly loom into appearance, shining with the reflected light of our doomed sun.

Do not imagine that these stars, when they die, remain dead. Death in the universe is resurrection. When a collision takes place between two suns or two worlds, both are instantaneously converted into nebulae—that wonderful substance out of which suns and worlds are born. This is not speculation. It has actually been observed. Ages pass and the nebulae condense into new suns, and new worlds. Ultimately these meet disaster; but the disaster as before results in birth. Creation is kept alive by catastrophes and explosions.

RUFUS O. SUTER, JR.

General Notes

Professor Herbert Couper Wilson, Associate Editor of ASTRONOMY AND ASTROPHYSICS 1892-1894, Associate Editor of POPULAR ASTRONOMY 1894-1909, Editor of POPULAR ASTRONOMY 1909-1926, died at his home in Northfield, Minnesota, in the early morning of March 9, 1940. A biographical sketch of Professor Wilson will appear in the next issue of this magazine.

Dr. Frederick H. Seares, astronomer and assistant director of the Mount Wilson Observatory of the Carnegie Institution of Washington, was awarded the Catherine Wolfe Bruce Gold Medal, "for distinguished services to astronomy" at the annual meeting of the Astronomical Society of the Pacific, which was held on January 27 in San Francisco. (*Science,* February 9, 1940)

The Hayden Planetarium of the American Museum of Natural History has acquired through the generosity of Lincoln Ellsworth a recently discovered specimen of an important meteorite fall. It is a complete specimen, weighing 522 pounds, and is part of the Bethany-Gibeon fall in Southwest Africa. It is the only one of the Gibeon group that has been brought whole to this country. The new meteorite, to be known as the Kirris-Ost siderite, will be added to the collection of meteorites. (*Science,* February 9, 1940)

Eros.—Dr. Fletcher Watson calls attention to the possibility of a short-period variation of one magnitude in the brightness of Eros near the time of opposition (June 16, 1940). Photometric observations during May, June, and July are

desirable; but they will be difficult for northern observers because Eros will be far south at the time and of the twelfth magnitude. (*H.C.O. Announcement Card* 519.)

The Rittenhouse Astronomical Society of Philadelphia held its regular monthly meeting on Friday, February 9, 1940, in the Hall of The Franklin Institute. The program was: "24 Hours at the Cook Observatory." The following lectures were presented: L. P. Tabor, "Photographing the Milky Way with the 10-inch Ross Lens"; I. M. Levitt, "The Solar Program"; J. S. Thompson, "Photoelectric Photometers"; Dr. Orren Mohler, "Bright-line B Stars."

Summer Conference on Astronomy

The fifth session of the Summer Conferences on Astronomy will be held at the Harvard Observatory from July 1 to August 10, 1940. It is believed that many scientists and teachers will welcome the special opportunities for discussion and research available during the six-week session. Visitors who wish to use the plate collection or the instrumental equipment will be accommodated to the greatest possible extent. Colloquia will be conducted twice each week by staff members and visiting scientists.

The conference will include:

Topics in Celestial Mechanics—Professor Dirk Brouwer, Yale University. A discussion of the theory and application of planetary perturbations.

The Internal Constitution of the Stars—Dr. T. E. Sterne and Dr. Martin Schwarzschild. An application of the laws of physics to stellar interiors and a comparison of the results with observation; an introductory course.

Introduction to Astronomical Optics—Mr. James G. Baker. A treatment of the general problem of astronomical optics with numerous illustrations of the designing of specific types of instruments, both in theory and in practical details.

Photographic Photometry—Dr. Cecilia Payne-Gaposchkin and Dr. F. L. Whipple. A comprehensive discussion of the problems of photographic photometry found in the study of point-images, surfaces, and spectra.

Opportunities for research under guidance will be available in the topics of the conferences and in the following topics: Galaxies, Astrophysics, Variable Stars, Photoelectric Photometry, Meteors, and Meteorites.

Professor Shapley and Dr. Watson, assisted by visiting lecturers, will present a survey course: *Introduction to Cosmogony*. The lecturers will consider origins, processes, and destinies; the subjects will include stars, galaxies, the structure of the universe, relativity, cosmic rays, the generation of stellar energy, ancient cosmogonies, mountain building, the age of the earth, planetary atmospheres, and the origin of the solar system. Among the visiting lecturers will be Professor Henry N. Russell and Professor H. P. Robertson of Princeton University, Dr. Lyman Spitzer, Jr., of Yale University, Dr. R. E. Marshak of the University of Rochester, Professor Kirtley F. Mather and Dr. I. A. Getting of Harvard University, and Dr. Daniel Norman of the Harvard Observatory. There will be two lectures and one discussion group each week.

As in 1939, auditors holding the degree Ph.D. in Astronomy, Physics, or Mathematics, will be allowed reductions in their fees. For further information inquire of the Harvard Observatory or the Summer School Office, Wadsworth House, Cambridge, Massachusetts.

Book Reviews

Sundials, How to Know, Use and Make Them, by R. Newton Mayall and Margaret L. Mayall. (Hale, Cushman and Flint, Boston, 1938. Price $2.00.)

The Mayalls have written an exceedingly interesting book on sundials. It would indeed be difficult to find a pair better qualified to write a book on the subject. Mrs. Mayall has for many years been chief assistant to Miss Cannon at Harvard Observatory, Mr. Mayall is a landscape architect. Sundials had been their hobby for a long time, but three years ago they turned professional when they became joint curators of the Ernst collection of sundials at Harvard. The book has been written with authority and deserves a place in the library of any individual or institution concerned with time keepers, ancient or modern.

The main body of the book is devoted to the construction of sundials of many different types and descriptions. In early chapters detailed instructions are given for the design and construction of simple dials, from which any ingenious ten-year-old can make a dial for the family backyard. Several refinements are introduced in later chapters, where the standard-time dial and heliochronometer make their bow. Professional astronomers, who have not made a special study of the subject will find here much that is new to them and parts of the book are invaluable for reference material in connection with elementary college courses in astronomy.

The last chapters of the book are devoted to a description of some dials of special interest. We find here every type of sundial from one small enough to be mounted on a man's finger ring to the giant dial of Jaipur in India, which in spite of its age of well over two hundred years, still holds the world record for size. Then we meet here the "noonday gun" (a dial which automatically fires a little gun at noon), the moon dial at Queen's College, England, and many others. The book is richly illustrated with helpful diagrams and excellent photographs of sundials. The frontispiece shows the giant dial at Jaipur, whereas the last photograph of the book is of the dial at Central Mall of the New York World's Fair. All of which goes to show that interest in sundials has by no means died out in our mechanical age.

B. J. B.

Unsolved Problems of Science, by A. W. Haslett. (The Scientific Book Club, 111 Charing Cross Road, London, W.C.2. Price to members 2/6.)

This volume was the selection by the officers of the Scientific Book Club for its members in June, 1939. With science occupying such a large place in all activities as it does today, a book of this nature will be of interest to practically every intelligent person. Although science is revealing heretofore unknown principles with astonishing rapidity, yet, paradoxically, the number of unsolved problems seems to be increasing. This is readily understood. With a greater comprehension of science and its methods of inquiry, many phases of the physical universe are recognized as unsolved problems which were not even thought of hitherto. Each problem which is solved brings with it others which require solution. Since the number of unsolved problems is very great, entirely beyond the scope of one volume, it is of interest, first of all, to know which of them an author would include in a book of a few more than three hundred pages.

Mr. Haslett, the author of the book before us, in addition to an introductory chapter and a summarizing chapter, includes twelve others, each devoted to one

such problem. They are titled as follows: The Creation of the Universe; Are there other Worlds than Ours?; This Changing World; Our Weather Cauldron; Messages from Space; The Origin of Man; The Beginnings of Civilization; Is Man a Machine?; The Riddle of Sex; Nature's Building Bricks; Mathematics or Common Sense; The Secret of Strength.

These questions are discussed intelligently and in such a way as to stimulate thought. To read it understandingly, one need have only such general scientific knowledge as any well read person possesses. The volume is to be recommended.

An Easy Guide to the Constellations, by J. Gall Inglis. (Gall and Inglis, London and Edinburgh.)

This pocket-sized volume is quite elementary in character as its title indicates. As such it will meet the needs of beginners, the class to which all astronomers belong at some time. The attention of the management of this magazine is frequently called to the fact that many readers prefer really popular articles. This small book would meet their needs admirably. Naturally one's first contact with astronomy should be a study of the sky. It is for this purpose that this little work has been arranged. The first twenty-four pages are devoted to brief comments relative to the more obvious phases of the heavens. The sun, the moon, the planets, comets, and meteors are briefly explained. Following this there are thirty star maps. These are circular in form and printed on a dark blue background, thus resembling the telescopic view if one's telescope covers a sufficiently wide field. These maps show the conspicuous stars in the several constellations, usually in relation to the neighboring bright stars. The pages facing these maps contain material descriptive of the maps, pointing out the special features.

It is a convenient and very useful supplement to the more elaborate star atlases.

Leander McCormick Observatory Publications.—A copy of Volume VIII of these publications, bearing the date 1940, has just been received. Its 750 pages are filled with the results of the enormous amount of work involved in the determination of the trigonometric parallaxes of 650 stars. It is stated that this work was done by S. A. Mitchell, Dr. Reuyl, and others. The first twenty-four pages are devoted to a description of the methods and measures, and discussions of the large body of data presented. This volume will take its place among other similar volumes of parallaxes and will doubtless be a source of information for workers in the field of the structure of the galaxy for many generations. Dr. Mitchell and his collaborators are to be congratulated upon the production of so extensive and so useful a volume.

Norton's Star Atlas, by Arthur P. Norton. (Messrs. Gall and Inglis, Edinburgh and London; obtainable from Eastern Scientific Supply Co., P. O. Box 1414, Boston, Massachusetts.)

The first edition of this useful work was published in 1910, the sixth in 1937, and the seventh in 1940. Improvements and additions have been made progressively in the several editions. From the preface of the copy before us we learn, "In this Seventh Edition, the Charts and Introductory Notes remain as in the previous one, but there have been added a revised and enlarged Index to Contents, a revised Index to Constellations, and Precession Tables. The chief addition is a re-arranged

and greatly extended list of Interesting Objects for the telescope. In previous editions the number of these Objects was 130; in the present book the number is increased to 523.

"The R.A. and Declination of the Objects in these lists have been reduced to the Epoch 1950, which will probably be a common standard of reference for many years to come."

We can still confidently use the sentence with which the review of the copy of the Sixth Edition was concluded, viz., "This work can be highly recommended as a volume of useful, convenient, and pertinent information in astronomy."

Modern Armaments, by A. M. Low. (Scientific Book Club, 111 Charing Cross Road, London, W.C. 2. Price 2/6 to members.)

It is, perhaps, a fair question whether "astronomy and allied sciences," the field this magazine is designed to cover, is extensive enough to include the science incorporated in a book of the above title. In ordinary times the answer would quite likely be in the negative, but at present the title has an unusual interest to scientist and non-scientist alike. This volume was the choice of the Scientific Book Club for October, 1939. It was, therefore, written before the beginning of the present war, and one notes some minor discrepancies between the theory propounded and the results of actual war. However, the book is so recent and the author was in such close touch with the points he discusses that much up-to-date and authentic information is contained in it. The potentialities of destructive warfare are appalling. The book creates or confirms the impression that the hope of humanity lies in preventing the full power of modern armaments from being brought into action. There are sixteen double-plate illustrations which would be exceedingly interesting if they were not so terrifying.

The Science Leaflet and **Science Observer,** copies of which came to our desk recently, the former a weekly pamphlet of some forty pages, published during the school year, the latter an eight-page, octavo-sized monthly, are issued by The American Institute of the City of New York. The former is intended for those interested in elementary science and is the official publication of the student science clubs of America and of the American Institute Science and Engineering Clubs. Both publications treat topics in current science in an interesting and popular manner. These may be obtained by addressing The American Institute, 60 East 42nd St., New York City. The annual subscription price is, for the Leaflet, $2.00, and for the Observer, fifty cents.

Publications Received.—The publishers of POPULAR ASTRONOMY hereby acknowledge the receipt of the following named publications and express their great appreciation of the courtesy shown on the part of those who have sent them.

Contributions from the Mount Wilson Observatory—

No. 604. "The Zero Point of the Period-luminosity Curve," by Ralph E. Wilson.

No. 605. "Spectrographic Elements for β Capricorni," by Roscoe F. Sanford.

No. 606. "The Spectra of Bright Chromospheric Eruptions from λ3300 to λ11500," by R. S. Richardson and R. Minkowski.

No. 607. "Rotation Effects, Interstellar Absorption, and Certain Dynamical Constants of the Galaxy determined from Cepheid Variables," by Alfred H. Joy.

No. 608. "Temperature Classification of Europium Lines," by Arthur S. King.
No. 609. "Second Report on the Expansion of the Crab Nebula," by John C. Duncan.
No. 611. "The Arc Spectrum of Europium," by Henry Norris Russell and Arthur S. King.
No. 612. "The Intensities of Sunspots from Center to Limb in Light of Different Colors," by R. S. Richardson.
No. 613. "On the Doublet Ratio of Interstellar H and K and the Absolute Magnitudes of Wolf-Rayet Stars," by Roscoe F. Sanford and O. C. Wilson.
No. 614. "Intercomparison of Doublet Ratio and Line Intensity for Interstellar Sodium and Calcium," by O. C. Wilson.
No. 615. "Proper Motions and Mean Absolute Magnitudes of Class N Stars," by Ralph E. Wilson.

STAR STUFF

When I look up at a star at night,
And think how its feeble ray of light
Has been on the way a thousand years
To reach the earth, it then appears
That the worth of man in the Universe
Is pitifully small.

This tiny globe of iron and rock,
Born of the sun in catastrophic shock,
Has given to man his humble birth
Within its infinitesimal girth—
Twenty-five thousand miles in space—
How pitifully small!

But I forget the human mind;
The eye that scans the sky to find
A hundred million galaxies
In whose vast depths lie energies
Unbounded, atoms, elements,
But none of man's intelligence
So pitifully small.

All matter in Infinity
Is only what man finds to be
Existent here for him to see—
Electrons in a baby's hand,
The stuff that makes a grain of sand,
Once danced within the sun's fierce flame;
And as the sun man is the same,
Though pitifully small.

Unnumbered worlds, in ordered files,
Move at that Will which was obeyed
When man was in His image made.
Then not in vain man came to birth
Upon this little spot of Earth:
He who is one with the Source of All,
Cannot be pitifully small.

—ELIZABETH NIXON.

1738 Seventh Ave., Greeley, Colorado.

Correction.—On page 127 of the preceding issue (March, 1940), line 19 from top, *for* large *read* small. This error is due to the editor, not to the author.

Ling.
ohn C.

Arthur

ifferent

Magni-
son.
rstellar

rs," by

om